RECLAMATION ASSESSMENT CRITERIA FOR PIPELINES
2001 DRAFT

1.0 GENERAL INTRODUCTION

Provincial regulations in Alberta require that land disturbed by pipelines must be reclaimed to an equivalent land capability. These criteria measure the return of equivalent land capability for pipelines.

To determine whether equivalent capability has been met, industry and government require a method of assessment which is reliable, replicable, and relatively easy to work with in the field. In October 1996 NOVA Gas Transmission Ltd. (NGTL) established a multi-stakeholder External Soils Advisory Board with the short-term objective of developing a user-friendly, capability-based soil evaluation tool to determine if equivalent land capability has been achieved after pipeline disturbance. Membership included Alberta Environment, Alberta Agriculture, Food and Rural Development, NOVA Gas Transmission Ltd. (now TransCanada PipeLines Limited), PanCanadian Petroleum Limited, Talisman Energy Inc., Can-Ag Enterprises Ltd., J. D. Burke and Associates Ltd., and Pettapiece Pedology.

Three years of development and field testing resulted in the *Reclamation Assessment Criteria for Pipelines – 2001 Draft*. Although many of the factors are relevant, it is not intended as a construction guide or to direct soil salvage. This document should, however, be considered when planning for pipeline construction.

This criteria document addresses three topics in separate sections:

- Section 2 describes a field protocol that provides a framework for the application of the specific reclamation assessment tools. It includes discussions of a number of field related issues, guidelines for determining pass/fail and a general field procedure.
- Section 3 describes the screening phase (Phase 1) to identify any problems or marginal situations. It includes Sections on the descriptions and ratings of landscape, soil and vegetation factors. It is relatively simple and quick with a minimum of documentation to support visual assessments.
- Section 4 describes the more detailed soil assessment (Phase 2) to clarify marginal situations and to identify specific soil problems (and solutions). It is a quantitative field assessment of soil capability modified from the standard Land Suitability Rating System (LSRS). Optional laboratory analysis may be used to verify field estimates of soil characteristics.

2.0 FIELD PROTOCOL

2.1. INTRODUCTION

This Section deals with how the rating systems, discussed later in Sections 3 and 4, should be applied. The specific field issues presented are those that have been identified through the activities involved in developing this manual.

2.2. FIELD PROCEDURE ISSUES

2.2.1. Map Units

2.2.1.1. Definition

A map unit is any length of right-of-way (RoW), longer than a specified minimum length (50 m), that appears different from the rest of the RoW in terms of topography, vegetation and/or soils (Figure 2-1). The differences may be due to natural, farm management or reclamation related features. In general, the smaller the area identified, the greater should be the contrast in characteristics. (See the discussion on "problem or spot units", Section 2.2.2).

2.2.1.2. Selection

It is common for all three components (topography, vegetation and soils) to co-vary. For example, in undisturbed situations, changes in vegetation are often linked to changes in soil conditions that are often linked to topographic changes. The usual process is first to use visible topographic and vegetation features to delineate map units. Subsequent soil observations, or more detailed vegetation and landscape observations, could result in the subdivision or refinement of the original units. Initial units should be subdivided only where there are visible contrasts between the RoW and Control. Do not subdivide on the basis of natural variation such as knolls or swales.

Examples of topographic differences include changes from relatively level to sloping or hilly terrain. A single hill or hummock is not to be considered a map unit unless it is longer than the specified minimum length (50 m) and occurs in isolation from other hills.

Differences in vegetation could include different growth (e.g., lower or higher), amount of cover or the inclusion of different species (including weeds).

Soil differences could include changes in wetness (> 1 drainage class), organic matter content (colour change of >1 unit of value), salinity (> 4 dS/m) or texture (> 1 class e.g., loam to clay or loamy sand).

Map units should be identified on a plan of the RoW.

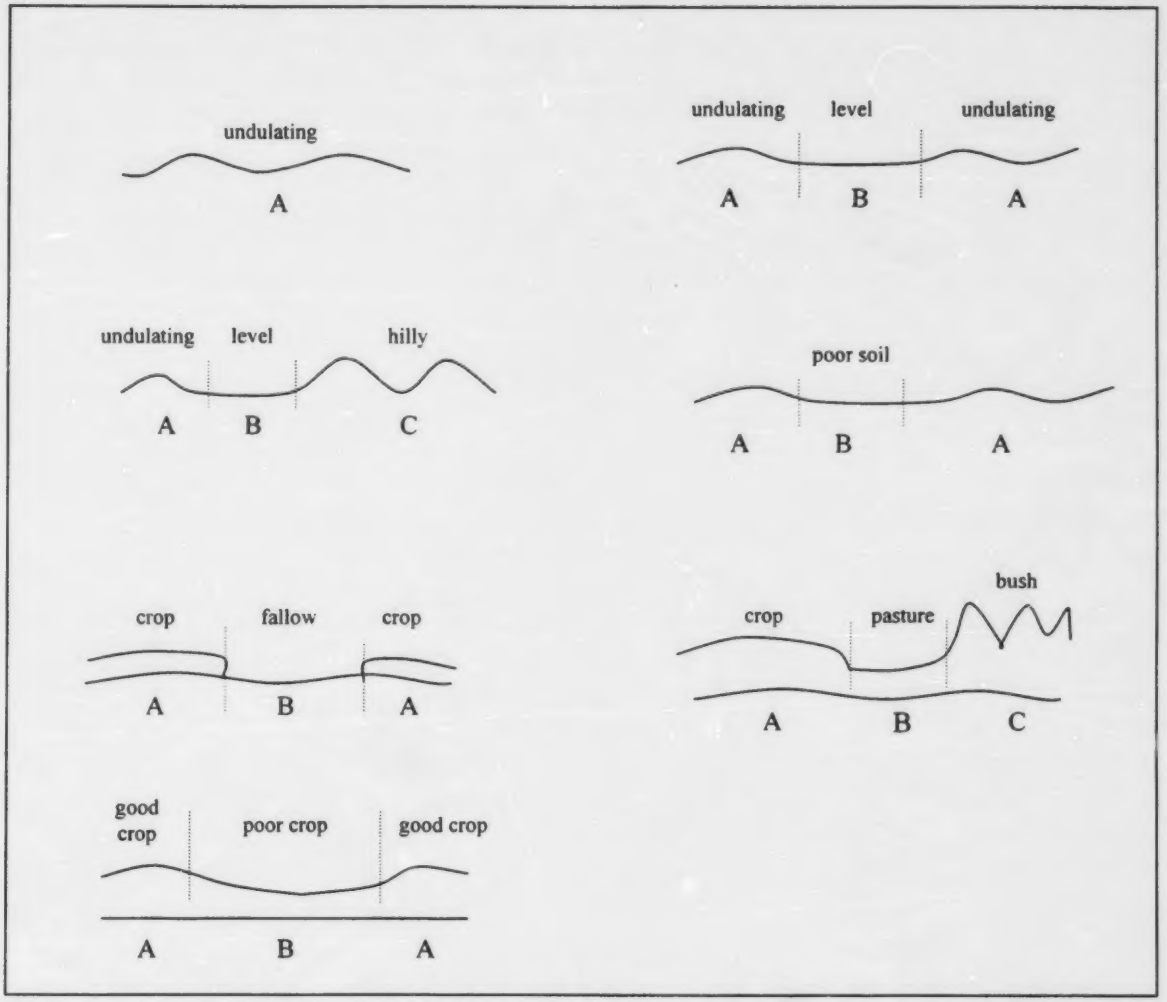


Figure 2-1. Example map units (based on 1 km or ½ mile length of line).

2.2.2. Problem or Spot Units

2.2.2.1. Definition

These units are any distinctly different (strongly contrasting) portion of the RoW that is less than the specified minimum length required for a "map unit". It is a special case of a map unit for recognition of very localized problems.

These are areas, often associated with microrelief or drainage problems, that affect or are affected by subsequent management. They commonly occur in areas of more intense pipeline activity such as road crossings, pipe-bends or crossovers, or in naturally sensitive areas such as stream crossings, seepage areas or saline areas. They may also be related to

third party activities such as off-road vehicle traffic or cattle crossings that often show up as areas with little or no vegetation (bare areas) (see Section 2.2.10).

2.2.2.2. Selection

Small problem areas should be identified and located on the RoW plan. A single spot will not fail a line segment but the accumulated effect of several spots is considered in the final assessment (see pass/fail considerations). The length of affected areas as well as the frequency and total proportion in a unit should be identified. This is a situation where sites may be located to determine boundary conditions rather than typical situations. It is also a situation where one needs to assess the impact on the overall management of the land unit. If these small areas control the land use then the whole unit should be rated down.

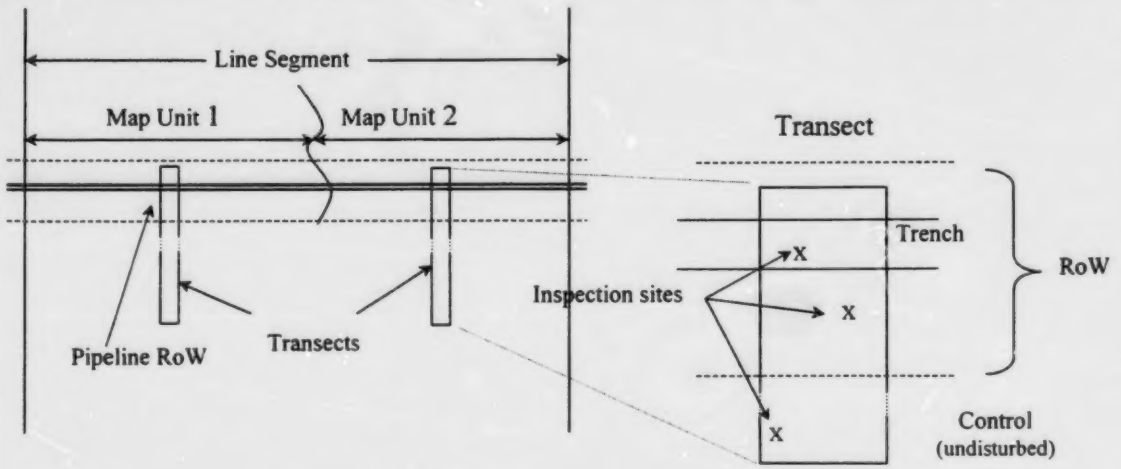
Small problem areas (areas with visible adverse affects) are often areas which, if they were identified, could be fixed.

2.2.3. Controls

2.2.3.1. Objective

The purpose of controls is to establish the amount of difference between the present condition and the undisturbed condition. They may be in the same location as prior to disturbance or in an appropriate, representative, preferably nearby off-RoW location after disturbance (Figure 2-2). The differences can be positive or negative.

The choice of controls is the key to a proper assessment. The control must be representative of the site under investigation and it must consider natural variability (see Section 2.2.7). It should be noted that natural variability in landform, vegetation, and soil characteristics is commonly greater in the undisturbed situation than in the disturbed areas so it is particularly important that care be taken to establish the appropriate control.



Line Segment:	Any section of pipeline (usually 0.8 to 1.6 km).
Map Unit:	Subdivision of a line segment based on differences in vegetation, landform and soils.
Transect:	A representative line or belt across the pipeline RoW and includes an appropriate undisturbed off-RoW control.
Inspection site:	A representative location on the trench (if identifiable), the RoW and control for assessing equivalent land capability.

(Full definitions are in the glossary.)

Figure 2-2. Schematic of terminology used in a pipeline reclamation assessment.

2.2.3.2. Selection

For Phase 1, the visual selection of an appropriate typical or representative control is the responsibility of the assessor. First, determine whether the RoW and the adjacent land can be directly compared: that is, is it the same crop or vegetation type, similar age and cultural condition (e.g., fertilization, grazing or harvesting). Controls established on adjacent land facilitate direct comparisons allowing for a simple, integrated view of stand condition. However, sometimes this is not possible such as when the vegetation type or land use in the adjacent land differs significantly from that on the RoW (e.g., forage through bush, or pasture through cultivation). When the vegetation is of similar type and age, but cultural practices vary (e.g., cut vs uncut forage), the focus should remain on the common vegetation features (e.g., plant density). Where vegetation composition on the RoW differs significantly from the adjacent land, but is suitable for the land use (e.g., grass in bush), vegetation on the RoW should be compared to similar vegetation and soils a short distance away or to expected performance of the vegetation type for similar soils in the geographic area.

For Phase 2, it is recommended that 2 to 5 subsites be assessed to establish the range in variability (3 is the usual number). It is also recommended for a Phase 2 assessment that there be a minimum of two transects in the unit and at least one transect per 100 m.

General considerations for Phase 2:

- For soils it is usual to make 3 or 4 quick inspections (probes) for features such as depth of A horizon or density of subsoil.
- For relatively uniform units, averages are quite appropriate. For more variable units or problem spots it is recommended that the range of conditions be documented.

It is important that equivalent landform positions be compared in both Phases. It would not be appropriate to compare a mid-slope RoW to a lower slope control (or vice versa).

2.2.4. Transects (Inspection Sites)

2.2.4.1. Objective

The purpose of an inspection is to characterize a unit or to establish the features associated with a problem area. For pipeline assessment, the basic unit is a transect across the RoW (Figure 2-2). It includes an inspection on the trench (if identifiable), the RoW and an appropriate off-RoW control (see section on controls). Documentation of a transect should include its location on the RoW plan and a statement of general landscape orientation such as "typical mid-slope" or "crest of hill" or "lower slope". Where the trench is not readily identifiable, one inspection on the RoW is required.

2.2.4.2. Selection

The most important concern is that the inspection site be representative of the area under investigation. This is critical and requires common sense, knowledge and experience. It includes an assessment of local, natural variability.

Some general guidelines are:

- Use obvious indicators, particularly vegetation, to select typical or representative sites.
- Do not choose a site near the unit boundary unless the purpose is to establish a boundary location.
- Mid-slope positions are generally the most representative in an undulating or hummocky area and are a logical location for a single initial site.
- If there is enough concern to warrant further investigations then the more extreme crest and lower slope landscape positions should be looked at.
- Identify all small (spot) problems and establish their extent.

The number of inspection sites selected in a map unit must support an informed, justifiable decision. The actual number will be dictated by the complexity of the area. **For Phase 1,**

the minimum number of sites in uniform areas should be 1 per map unit with at least 1 per quarter section (about 0.8 km or ½ mile). For Phase 2, there will generally be more inspections with 2 to 4 in a map unit being common to establish severity and extent of problems.

2.2.5. Minimum size area

2.2.5.1. Objective

Guidelines need to be established as to the smallest length of RoW that will be identified and managed in the general mapping process. The minimum size should be reserved for fairly contrasting situations such as differences in drainage of two or more classes, severely eroded areas or areas that represent apparent reclamation problems. This does not mean that smaller "problem" areas should be ignored. It is a guide for general context and orientation.

2.2.5.2. Selection

For pipeline construction preplanning, the general recommendation has been to use 100 m as a minimum length for considering the application of different pipeline soil handling methods. This is based on general construction considerations and appears quite reasonable. However, there could be, for any number of legitimate reasons, significant reclamation concerns that are less than 100 m but should be considered in a general assessment. As a starting point we suggest the use of **50 m as the minimum length** for routine considerations (see Section 2.2.1 on "map units" and Section 2.2.2 on "problem or spot units").

2.2.6. Displaying pipeline context

It is important that the general field situation be documented so that a third party can properly evaluate the conclusions of the assessment. A principal component of the documentation should be a diagram showing, as a minimum, the general location of the pipeline (RoW), the limits of map units, the location of transects and the location of any problem spots (particularly those with safety considerations). The location of any pertinent property/landowner boundaries should also be shown (Figure 2-3).

A scale of at least 1:10,000 (10 cm/km or about 6 in/mile) is appropriate to locate all pertinent features.

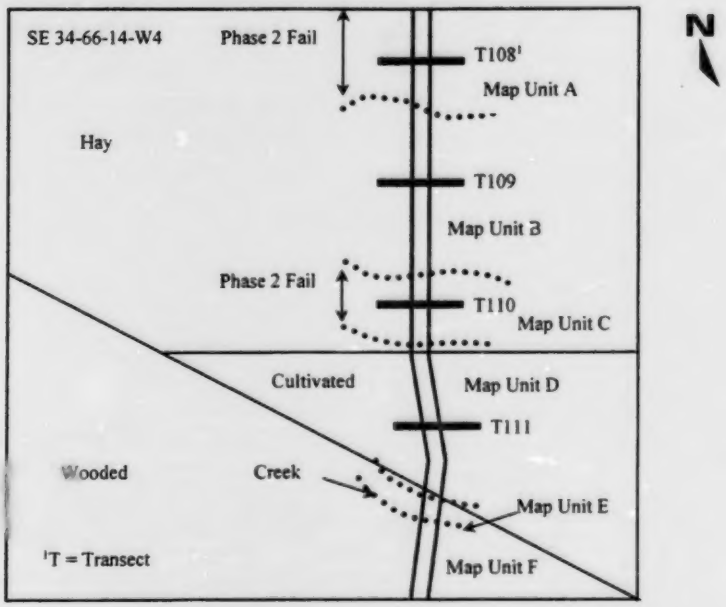


Figure 2-3. Example of a RoW diagram

2.2.7. Variability

Variability, a range in characteristics, is an inherent part of any natural system. It is found in landscape attributes such as slope, microrelief, stoniness or drainage. Vegetation will show variability in composition, size, vigor and yield, while soils will exhibit a range in features such as topsoil depth, organic matter content or salinity. Grain yields commonly show ranges of 50% or greater across a field. An average yield of 40 bu/ac wheat can be made up of areas with yields from 20 (or less) to 50 (or more) bu/ac. Topsoil depth in the Black Soil Zone can range from 5 to > 40 cm with individual fields showing ranges of about 9 cm around an average of 16 cm. The variation can be just as large along the RoW and trench as for the off-RoW controls.

Variation must be acknowledged and accommodated in any natural resource assessment. The challenge is to determine what combinations of features and ranges in values are critical. Examples of this may be found in various capability assessments.

It is helpful to establish, for each map unit, a concept of least, most and average or typical conditions. The variability should reflect predictable slope position and aspect situations. The assessment of average or typical conditions is critical for the establishment of representative RoW and Control sites.

2.2.8. Equivalent land capability

Soil capability assessments have already determined which of the soil characteristics are critical (texture, pH, organic matter content, structure, etc.) and have integrated them into a single value. This means that the individual attributes do not have to be analysed separately and the resultant value can be used to easily compare one site to another. However, this does not accommodate the inherent or natural variability around a site that is required to assess equivalency on an area basis.

To accommodate natural variation, any definition of equivalency must recognize a zone of tolerance within which all values can be considered "equivalent". Research and experience have shown that a value of 80% of the maximum represents a practical approximation for most natural landform attributes. This should apply equally to size of hills, depth of topsoil or yields of crops. It also applies to the range of variability associated with any particular attribute. That is, 80% of the variation will account for all but a few of the more extreme values.

The above consideration can be turned around to help define a practical "tolerance" for equivalency. If 80% of the range accounts for most of the variation then it can be assumed with some assurance that a tolerance of +/-20% should represent a given attribute measurement. That is, for any value 20% lower than a given value there is likely another that is 20% higher. As we get beyond the 20%, the likelihood increases that it is a real difference and not simply natural variability. For some landscapes the zone of tolerance might be as low as 10% while others might be so variable as to make any value questionable. However, a tolerance of +/-20% will accommodate the variability in the majority of landscapes and is recommended for inclusion in the definition of equivalent land capability.

That is, **for the purposes of these criteria, Equivalent Land Capability is achieved when RoW values fall within 20% of control values.**

2.2.9. Topsoil

Topsoil is an important soil feature in any assessment of value or capability relating to plant growth. Unfortunately, it has a variety of definitions which make the use of the term unclear. A common synonym is "surface soil" but this is not coincident with all definitions of topsoil, some of which have an organic matter component.

Some definitions refer to the cultivated layer (Ap horizon). This is consistent with "surface soil" and clearly identifies a lower boundary. However, not all soils are cultivated. Another common usage identifies it as, "the uppermost layer of mineral and organic material, valued as a growing medium, and ordinarily moved in tillage or its equivalent in uncultivated soils". This contains the essence of the value of topsoil and is the basis for conservation considerations. However, not all surface soils are rich in organic matter. Eroded soils, or exposed subsoil, may be very low in organic matter as are many of the

natural forested (leached, Ae horizon) soils and of course excavation spoils that may be at the surface.

The above items are indeed all part of our concept of topsoil. But, a definition that encompasses all these situations is cumbersome and not easily applied in an operational assessment system. Some compromise is required.

The following considerations are relevant:

- the basis of equivalent capability revolves around plant growth,
- the majority of plant roots are found within 15 to 20 cm of the surface, and
- normal cultivation depths range from 8 to 20 cm.

Based on the above, the following working definition is proposed for use in Phase 2 assessments.

> Topsoil is the uppermost layer of mineral and organic material, valued as a growing medium, and ordinarily moved in tillage or its equivalent in uncultivated soils. Its characteristics are the average of the top 20 cm, or to a shallower root restricting layer, for both cultivated and uncultivated soils. It is referred to as the "surface soil" or "surface layer".

It is recognized that this is a compromise, but it includes the basic intent of topsoil and can be applied to all situations with a minimum of controversy. **It is suggested that the basic data collection describes and records all readily discernable (contrasting) horizons or layers and that averaging takes place as a separate activity.**

There are several aspect of the issue that have not been discussed. One of these is admixing. This assessment of the amount of mixing of subsurface material with organic rich "topsoil" has been an integral part of earlier assessments. This is a difficult assessment and we feel that it is covered by considerations of organic matter content, and structure. Another is the fact that cultivation depth is typically about 8 to 10 cm in the Brown Soil Zone, 10 to 15 cm in the Dark Brown Zone and 12 to 20 cm in the rest of the province and we are suggesting a single depth of 20 cm. Both of these considerations have been addressed with simplified assumptions to promote ease of consistency of application.

2.2.10. Special Circumstances

Situations may be encountered where the strict application of the system fails the site but where:

- there is no negative impact on the present (intended) land use; and,
- any remedial action is likely to result in either increased environmental risk or loss of productive use of the land for a period of time.

or

- there were written agreements at the time of construction that either sanctioned or requested a particular procedure that may result in reduced surface soil quality.

Examples of the first kind of special circumstances are fairly common in pasture/native range situations where vegetation suits the land use but where there may be minor roach, subsidence, low organic matter or weed issues. These are not "equivalent" to the control but they are not limiting for the land use. In addition, any remedial action could involve the destruction of present vegetation and, particularly in sandy or sloping areas, could pose significant erosion risks.

The second kind of special circumstance covers two common situations. One is the case of pipelines that were constructed before topsoil salvage was required (pre-1983). Many of these lines may not meet today's standards of equivalent soils, but they may be "grandfathered" because they did follow the rules of the day. The other case is the situation where a "no-strip" procedure is requested by the regulator or landowner. This is particularly common on native range where it is deemed preferable to have the least possible land disturbance. Again, it is possible that soils over the trench may not be of equivalent capability, but this has been balanced by minimum RoW disturbance. Confirmation of age of pipeline, Conservation & Reclamation (C&R) approval, surface disposition on public lands or owner request in writing are required to support these cases.

Another type of situation that is considered a special circumstance is that of third party impacts. These are situations where someone or some activity beyond the control of the pipeline operator (and often the land manager as well) has compromised the integrity of the reclamation effort. The use of the RoW as a trail by cattle is a common occurrence in pasture situations. This can significantly affect both the vegetation and microrelief but is not controllable by the operator. A more common and serious impact is that caused by the operators of off-road vehicles (bikes, quads, etc.) who often use the pipeline RoW as an access route into forested areas.

Land use is the key to these special circumstances considerations with adequate vegetation as the usual criterion. However, there are other circumstances that might be considered as "special":

- Landscape circumstances
  - erosion control berms on slopes
  - a raised RoW (causeway) through a wet area that might be used for access
- Soil circumstances (as described above)
  - minimum disturbance trenching on native prairie
  - reclamation done before topsoil salvage requirements came into effect in 1983

- Vegetation circumstances
  - vegetation absent for any natural reason (cultivation, burning, harvest) but landscape and soils are fine
  - vegetation is poor but there is a reasonable explanation (e.g., early succession) and where the problem can be readily addressed (e.g., weeds)

2.3. DETERMINATION OF PASS/FAIL

2.3.1. General Pass/Fail Considerations

This is the assessment of the success of reclamation to meet the requirements of "equivalent land capability". It is judged through a comparison with undisturbed conditions.

There are many components to a pass/fail assessment including degree, extent and cause of failures. For example, a minor problem of little extent should not be a reason for failure but if it covers a large area then it should be considered. Likewise, a severe problem posing safety or health risks of even a very small extent must be addressed. Therefore it is necessary for the guidelines to cover the variety of situations that might be encountered. The guidelines must recognize natural variability (see Section 2.2.7 on "variability" and Section 2.2.8 on "equivalent capability") and practicality while protecting the integrity and value of the natural resource.

Pass/fail guidelines address transects and line segments for both Phase 1 (screening phase) and Phase 2 (detailed investigation). The guidelines also address unique situations where special circumstances might be considered. These are mainly based on land use expectations and performance. It is emphasized that the assessment itself must be a balanced objective approach without a specific bias to either passing or failing.

2.3.2. Pass/Fail of a transect (site)

Site evaluations are reasonably specific and, with the opportunity to establish appropriate landscape controls, assessment variability is minimized but is still subject to the +/- 20% buffer.

2.3.2.1. Pipeline Reclamation Assessment Phase 1

This assessment considers landscape, vegetation and soil components along a transect across the RoW (see Sections 2.2.3 on "controls" and 2.2.4 on "transects"). The emphasis is on visible or surface attributes and a comparison between RoW and control conditions. The assessment includes documentation of both positive and negative differences between the RoW site(s) and the Control, **but only the negative values are considered for the determination of pass/fail.**

The conditions for pass or fail of a transect by the Phase 1 rating are:

Pass	• no negative results • one "-1" of any factor
Conditional	• two "-1" ratings for any combination of factors
Fail	• a "-2" rating for any factor, or • three (or more) "-1" ratings for any combination of factors

2.3.2.2. Pipeline Reclamation Assessment Phase 2

This assessment is a more detailed investigation of soil attributes that may be responsible for failures or conditional passes as noted in Phase 1. It uses a modification of the Land Suitability Rating System (Agronomic Interpretations Working Group 1995). Again, the RoW (and trench if assessed) is compared to a control. As with Phase 1, both positive and negative differences between the RoW site(s) and the Control should be recorded, but **only the negative values are considered for the determination of pass/fail**.

The conditions for pass/fail of a transect by Phase 2 are:

Pass	• any rating that is within the defined tolerance of 20% of the Control (= or > 80% of the Control)
Conditional	• any rating that is just outside the equivalent tolerance (65% to 80% of the Control)
Fail	• any rating that is significantly less than the Control (< 65% of the Control)

2.3.2.3. Summary of the pass/fail conditions for a transect

The specific conditions for pass/fail in Phase 1 and Phase 2 are different (Table 2-1) but the concept is the same. There is a 20% buffer to recognize natural field variation in both. The "-1" and "-2" ratings in Phase 1 are more or less equivalent to the 80% and 65% of Control expressed in Phase 2.

Table 2-1. Summary of conditions for pass/fail of a transect.

	Phase 1 (number and level of negative ratings)	Phase 2 (% of control)
Pass	- no negative results - one "-1" rating	≥ 80%
Conditional	- two "-1" ratings	65% to 80%
Fail	- a "-2" for any factor - three or more "-1" ratings	<65%

Note: Location of the failures should be documented as to trench or RoW for segment rating and review purposes.

2.3.3. Pass/fail of a line segment

A line segment is any designated length of RoW. It will normally be 0.8 to 1.6 km (1/2 to 1 mile) to correspond with common ownership extents of quarter sections and sections. It may contain one to several map units. It could also be related to natural features (such as map units) for tracts where ownership is not an issue.

The general premises are that map units (see Section 2.2.1 on "map units") have been appropriately identified and characterized and, that both the severity and extent of failures should be considered.

2.3.3.1. Phase 1

Any line segment shall pass if there is:

- < 50 m of continuous RoW (or trench) failure,
- < 100 m of accumulated length of non-continuous failures (problem spots, small map units), and
- there are no areas (no size limit) that present a safety hazard.

If the above three requirements are met, BUT there is > 150 m of "conditional" rating in a line segment then a Phase 2 assessment must be conducted.

2.3.3.2. Phase 2

Any line segment shall pass if there is:

- < 50 m of continuous RoW (or trench) failure,
- < 100 m of accumulated length of non-continuous failures (problem spots, small map units),
- < 150 m of "conditional" rating, and
- there are no areas (no size limit) that present a safety hazard.

Note: - 150 m of RoW represents about 20% of 0.8 km (1/2 mile)
- Any attribute causing a reduction of > 50% of the control should be noted.

2.4. FIELD PROTOCOL

2.4.1. Pre-field preparation

One should have pipeline alignment sheets if they are available. It is useful to have air photos as an aid in delineating map units. It is also necessary to have permission to traverse the lines. A working knowledge of the requirements and application of the assessment systems is required. In the case of Class 1 pipelines, the C&R information and approval conditions (if any) can also be helpful. For Class 2 pipelines company environmental plans, if available, may also be useful. **Before doing any excavations call Alberta First Call for the location of any hot lines in the immediate area.**

2.4.2. Field Procedures

2.4.2.1. Traversing and mapping.

It is expected that the RoW will be traversed on the ground by foot or motorized vehicle (quad, truck).

Initial mapping should be based mainly on the off-RoW situation using visible features such as topography and vegetation. Air photos are very helpful for this activity. Map unit boundaries should be documented on the alignment sheets or a line segment diagram. Soil features or RoW features noted during subsequent activities may be used to subdivide the initial units or to identify "problem spots". Again, any modifications should be documented. See Sections 2.2.1 on "map units" and 2.2.2 on "problem or spot units" for more detail.

2.4.2.2. Observations and records

Observations should be recorded documenting the general features of the map units (used to delineate the units). These include general landform features such as hilly, undulating, level or any obvious soil material features such as sands, clays, stones, till. Vegetation notes should include major land use features such as crops, forages, native range or forest, and general comments on plant health (e.g., good growth or poor germination) or the presence of undesirable species (e.g., weeds). Two or three sentences should be adequate. The **Phase 1 Transect Data Collection Form** (Appendix 3) outlines the minimum information required.

Site and transect specific observations should be recorded with the appropriate assessment (Phase 1 or Phase 2).

2.4.2.3. Application of Phase 1

The first step is to establish a representative transect across the RoW for each identified map unit. See Sections 2.2.3 on "transects" and 2.2.4 on "controls" for more detail.

The transect will consist of 2 or 3 sites: one site on the trench area if this can be located or identified, one site on the RoW work area and an off-RoW control site. There are many

instances where the trench location is not easily located or identified in which case only RoW and control sites will be assessed.

The general approach should be to make an observation where you think the trench might be but to not spend an inordinate amount of time trying to verify its location if not readily apparent.

Observations should be recorded on the Phase 1 field sheet. A preliminary site assessment should be made to determine whether there should be some modification of the map unit boundaries or if a more detailed Phase 2 should be initiated.

2.4.2.4. Response to a transect (site) assessment

If a transect passes then one proceeds to the next map unit (and, once all transects in the line segment are completed, to the line segment assessment) (Figure 2-4).

If a site fails, the first response should be to re-evaluate the appropriateness of the transect to represent the map unit in which it is located (i.e., its representativeness). If there is a question about the vegetation pass/fail, one should consider using a quadrat assessment (Section 3.5.4).

If the transect is not representative then proceed with a redefinition of the extent represented by the transect (re-map the unit under question). Re-mapping may also occur if one notes any problem spots. Remapping will result in the delineation of smaller units (which will each require assessment). Remapping may also trigger a Phase 2 if not done previously.

If the transect appears to represent the map unit then the "fail" is accepted and a Phase 2 should be conducted to clearly identify the problem. In cases of obvious landscape problems such as roaches, subsidence or stones, a Phase 2 might not be required as the reason for failure is clear.

When satisfied that the extent has been properly defined then proceed with the line segment assessment.

At the same time, a conditional rating for a map unit > 150 m in length or a failure of any length triggers a Phase 2 assessment. Phase 2 should be initiated if the reason for failure or extent of failure is not clear. **If the reason for failure is clear then a Phase 2 is not required; simply document and proceed with assessment**.

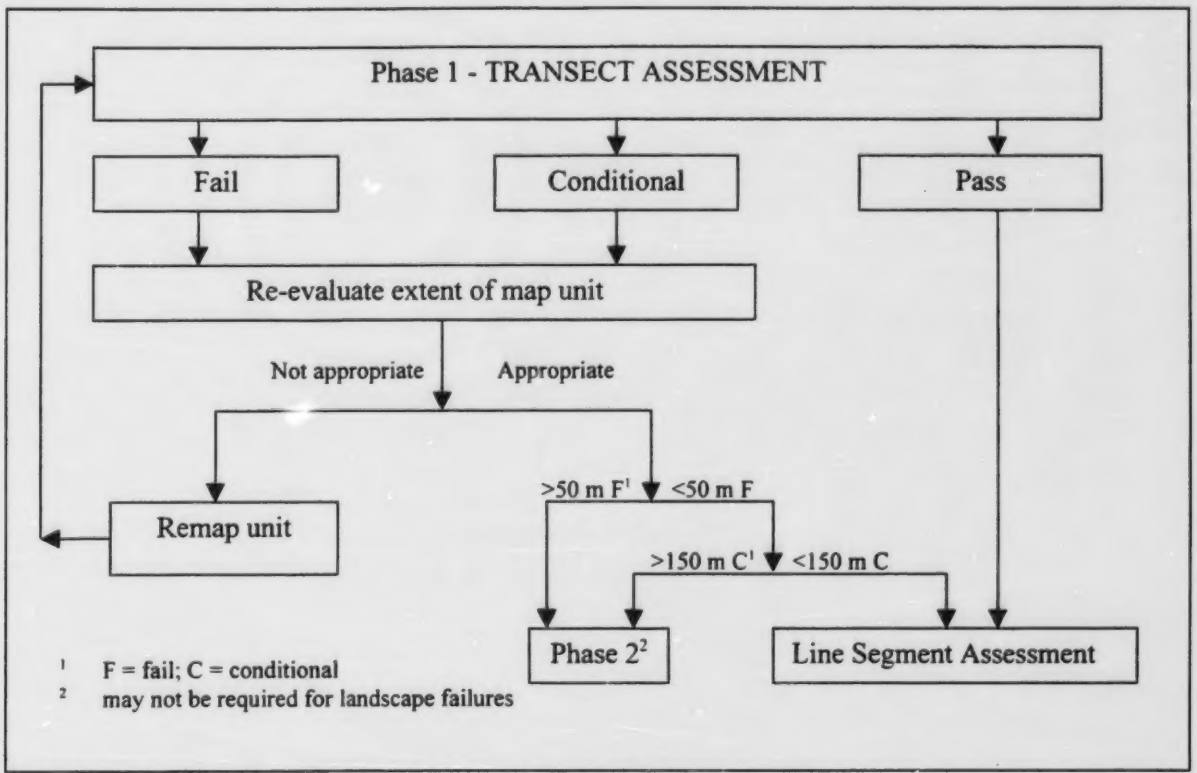


Figure 2-4. Flow chart showing response to a Phase 1 transect assessment.

2.4.2.5. Identification of problem units

Any small problem areas (1 to 50 m in length) noted during the traverse should be documented on the RoW plan (and air photo) to assist in supplementary reclamation efforts.

2.4.2.6. Application of Phase 2 (as required)

As with Phase 1, the first step is to establish a representative transect. It may be the same transect as used for Phase 1 or a new one if re-mapping has taken place. The objective here is a more detailed investigation of the soil features.

The more detailed investigation includes two aspects: a consideration of variability and the application of the Phase 2 assessment system.

The assessment of variability usually involves a look at several subsites in the same general location (See Section 2.2.4 on controls). The results should be recorded as a range in the measured characteristics but the application of Phase 2 may be done using average values for the site.

The assessment activities should be documented on the appropriate field sheets.

2.4.3. Final assessment and reporting

Line segment reclamation assessment follows the accompanying flow chart (Figure 2-5). The criteria for the line segment pass or failure are essentially the same for Phase 1 or Phase 2. This means that it does not matter whether a particular map unit was evaluated using Phase 1 or Phase 2. The one exception is the case where there is > 150 m of a "conditional" rating. This situation triggers a Phase 2 assessment (does not allow a pass/fail judgement).

The form, **Line Segment Rating Form** (Appendix 3), must be completed for each line segment and attached to the reclamation certificate application.

The results of the assessment should include a statement of pass or fail for each line segment. Failures should be supported by itemized (short) reasons for failure and include the map unit lengths. For example:

Fail:

- 200 m of 10 to 30 cm roach, or
- 75 m (map unit 2) of lower capability soils (surface structure), or
- 150 m of inappropriate vegetation (weeds).

It is at this point that one should document any special circumstance. This should include statements about the impact on present (intended) land use and the particular situation involved (e.g., prior agreement, no vegetation). See discussion in Section 2.2.10 on "special circumstances" for more detail.

Certificate application should not be made if failures are found unless accompanied by detailed justification for the failures. The reclamation inspector will review the justification and make the final decision on whether or not to certify all or part of the pipeline. **Operators must be aware that failure justifications do not automatically lead to a reclamation certificate**.

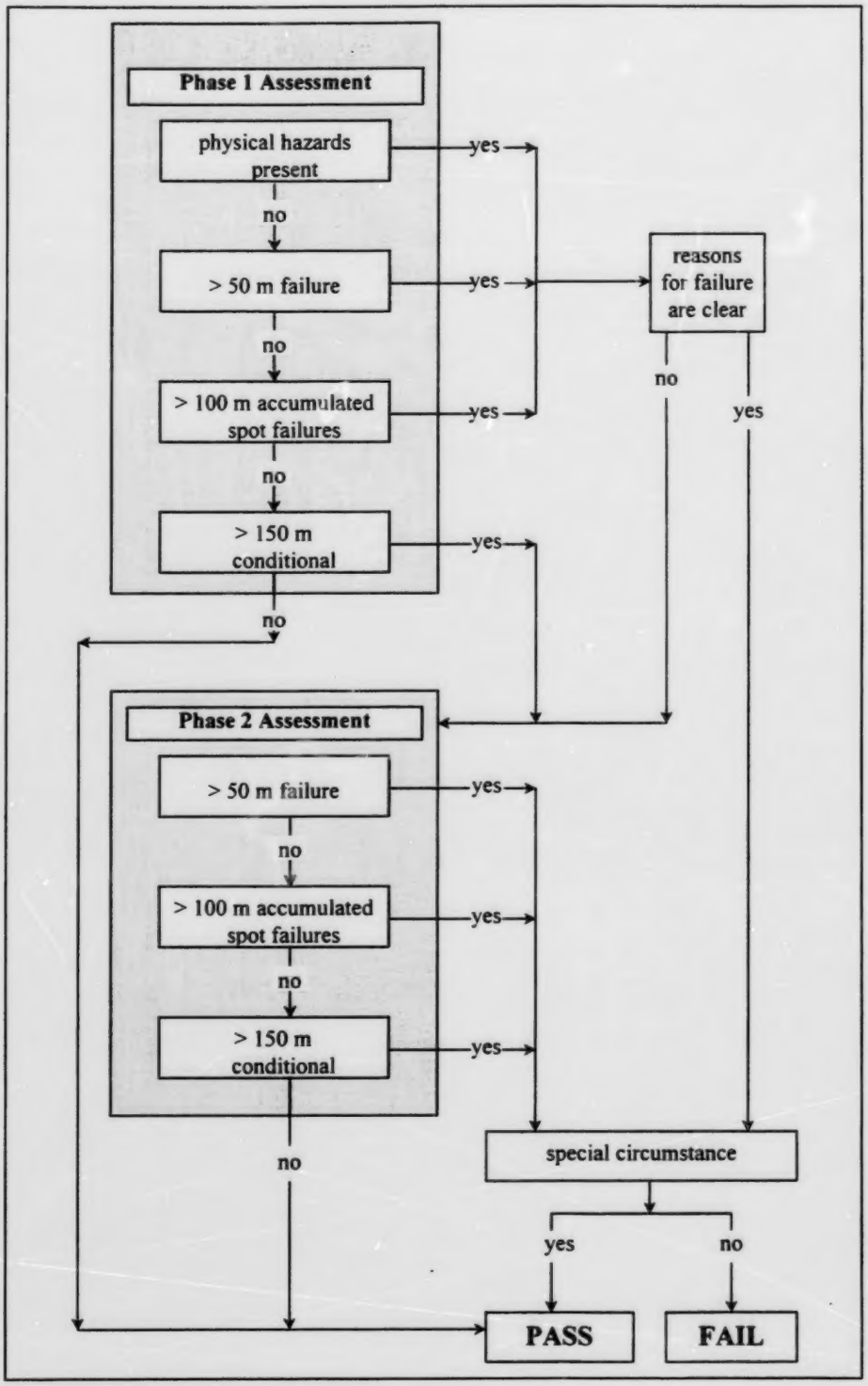


Figure 2-5. Flow chart for line segment rating.

3.0 PIPELINE RECLAMATION ASSESSMENT PHASE 1

3.1. INTRODUCTION

The focus of Phase 1 is to assess reclamation success along a RoW and to identify any areas that have significant changes in land capability as a consequence of construction or reclamation practices. No effort is made to quantify (such as assigning a soil capability rating) whether reclaimed areas are better or worse than controls. Rather, the objective is to document the extent and degree of landscape, soil and vegetative differences between the RoW and control and to determine if the differences are significant enough to warrant additional investigation (Pipeline Reclamation Assessment Phase 2).

In Phase 1, eight sub-categories of landscape, soils and vegetation (Table 3-1) on the RoW and control are observed, compared and assigned ratings based on the tables provided in this report. All comparisons assume consideration of natural variability (Section 2.2.7). The landscape, soils, and vegetation factors that are comparable between the RoW and control are assigned a rating of "0". Factors that are visibly weakly to moderately contrasting between the RoW and control are assigned a rating of "1". Factors that are strongly contrasting between the RoW and control are assigned a rating of "2". The differences may be positive (+) indicating that the RoW was improved (higher capability) during reclamation, or negative (-) indicating that the RoW was negatively impacted during reclamation (lower capability).

After the ratings for the eight sub-categories are determined, the final rating is calculated **using only the negative values** (see discussion of pass/fail in Section 2.0, Field Protocol). The ideal goal is to have a rating of "0" which indicates that the reclaimed RoW and controls are comparable. A "conditional" category is recognized to draw attention to possible problems while a failure results in the immediate invocation of a more detailed Phase 2. **The Phase 1 Transect Data Collection Form and Phase 1 Transect Rating Form are provided in Appendix 3 and must be attached to the reclamation certificate application.**

Table 3-1. Soil, landscape and vegetation categories in the Phase 1 assessment.

Component	Factor
Landscape	Surface drainage
	Coarse fragments (stoniness, wood, etc.)
	Microtopography
Soils	Colour
	Surface aggregate size and strength (tilth)
	Texture
Vegetation	Plant growth
	Composition

3.2. LANDSCAPE

The Landscape category contains three sub-categories; drainage, coarse fragments and micro-topography. Each of the three categories is described in detail in Sections 3.2.1 to 3.2.3.

3.2.1. Drainage

Soil drainage (moisture regime) is important for not only plant growth but also for land management. The surface and sub-surface drainage on a reclaimed landscape must be consistent with the original, undisturbed landscape with respect to drainage pattern, direction and capacity. Changes to drainage will result in a change in soil capability and may result in the need for special management practices.

Landscape drainage can be described in terms of ponding - the amount and duration of surface water. Description and ratings for changes in drainage are presented in Table 3-2.

In cases where the RoW and control are the same, a rating of "0" is assigned. Situations where soils and landscapes exhibit evidence of temporary or seasonal ponding on the RoW, but not on the control are assigned a rating of "-1". When the RoW shows evidence of temporarily improved drainage compared to the control the rating should be "+1". Situations where soils and landscapes have semi-permanent or permanent ponding on the RoW, but not on control are assigned a rating of "-2". When there is semi-permanent or permanent ponding on the control but not on the RoW, a rating of "+2" is assigned.

Improved surface drainage will generally increase capability. However, if existing or desired land use is a wetland for waterfowl habitat, then improved drainage may be undesirable. That is, ratings must be consistent with prescribed land use, therefore, two options are presented in Table 3-2.

Table 3-2. Drainage rating.

Description	Upland Rating	Wetland Rating
RoW and Control have the equivalent surface drainage.	0	0
Temporary or seasonal ponding on or caused by the RoW, not (previously) on the Control.	-1	-1
Temporary or seasonal ponding on the Control but not on the RoW.	+1	-1
Semi-permanent or permanent ponding on or caused by RoW, not on Control.	-2	-2
Semi-permanent or permanent ponding on the Control but not on the RoW.	+2	-2

3.2.2. Coarse Fragments

The presence of coarse fragments impacts the capability and management of soils and landscapes. Coarse fragments include stones, gravel and wood fragments. Stones and wood fragments are defined as coarse fragments >10 cm in diameter and gravel is defined as coarse fragments <10 cm in diameter. Wood fragments <10 cm in diameter are classified as having no or minor impact on soil capability and are not considered in the Phase 1 system. The classes used for assessment of the degree of stoniness were defined by the Soil Classification Working Group (1998) (Table 3-3).

Table 3-3. Coarse fragment classes (adapted from Soil Classification Working Group 1998).

Class	Description
S0	None to few stones or wood fragments on surface. Stones or wood fragments typically more than 25 m apart.
S1	Occasional stones or wood fragments on surface. Stones or wood fragments typically 8 to 25 m apart.
S2	Numerous stones or wood fragments on surface. Stones or wood fragments typically 1 to 8 m apart.
S3	Many stones or wood fragments; serious impediment to surface activities (machinery, vehicles). Stones or wood fragments typically 0.5 to 1 m apart.
S4	Very many stones or wood fragments on surface; considerable clearing required before any surface activities possible. Stones or wood fragments typically 0.1 to 0.5 m apart.
S5	A boulder or stone pavement. Stones or wood fragments typically <0.1 m apart.

The number and size of coarse fragments on a reclaimed RoW should be similar to control areas. Increases in coarse fragment content may result in a decline in soil capability and require special management practices by landowners. The ratings and description of coarse fragments are presented in Table 3-4.

Surface gravel usually reflects subsurface gravel contents. Gravel contents of less than 15% (by volume) are not generally considered to be a problem, but major changes in gravel content over 15% can affect vegetation growth and land management. Relative changes of < 25% (5% in a soil with 20% gravel or 15% in a soil with 60% gravel) have little impact and are hardly noticeable. Relative changes of 25% to 100% (up to double) can affect water holding capacity, but will have a relatively minor impact on any management options. Changes of greater than 100% can have significant impacts on both moisture supply and management.

In cases where the RoW and control have an equivalent amount of stones or gravel, a rating of "0" is assigned (Table 3-4). Landscapes that have a minor change in the number of stones or gravel are assigned a rating of "-1" or "+1". Landscapes that have a major changes in the number of stones or gravel are assigned a rating of "-2" or "+2".

Coarse fragment ratings only apply to soils with greater than 15% gravel content (<15% is not considered a problem).

Table 3-4. Coarse fragment ratings.

Description	Agricultural Land Rating	Range/Forest Land Rating
RoW and Control have the **same** proportion of coarse fragments	0	0
Increase of 1 coarse fragment class; or 25% to 100% relative increase in gravel (by volume) between RoW and Control	-1	0
Decrease of 1 coarse fragment class; or 25% to 100% relative decrease in gravel (by volume) between RoW and Control	+1	0
Increase of 2 coarse fragment classes; or >100% to 200% relative increase in gravel (by volume) between RoW and Control	-2	-1
Decrease of 2 coarse fragment classes; or >100% to 200% relative decrease in gravel (by volume) between RoW and Control	+2	+1
Increase of 3 or more coarse fragment classes; or >200% relative increase in gravel (by volume) between RoW and Control	-2	-2
Decrease of 3 or more coarse fragment classes; or >200% relative decrease in gravel (by volume) between RoW and Control	+2	+2

3.2.3. Microtopography

Microtopography is defined as topography at a detailed scale. More specifically, in the case of a reclaimed RoW, microtopography refers to rills, gullies, blowouts, roaches and subsided areas created as a result of pipeline construction. The change in the degree and number of rills, gullies, blowouts, roaches or subsided areas along a RoW impacts land management and land capability by increasing the number of obstacles that a landowner must navigate. In some cases, microtopography may be severe enough to create safety hazards. Examples of safety hazards may include tension cracks or evidence of slope movement (slumping). The process by which the microtopography was created or changed is important for reclamation but not for the

reclamation evaluation. Therefore, man-made or natural processes are not separated for this assessment.

Both the degree and number of rills, gullies, blowouts, roaches and subsidence are important for consideration during reclamation evaluation (Table 3-5). In cases where the RoW and control are the same, a rating of "0" is assigned. Landscapes that have minor differences in the degree and quantity of rills, gullies, blowouts, roaches or subsidence (as defined in Table 3-5) are assigned a rating of "+/-1". Landscapes that have major differences in the degree and quantity of rills, gullies, blowouts, roaches or subsidence (as defined in Table 3-5) are assigned a rating of "+/-2". As a guideline, **it is suggested that elevational changes should be assessed over distances of up to two times the height of the feature in question**. That is, a 20 cm change in elevation over less than 40 cm distance would be considered an impediment, but that same height over 10 m, for example, would not.

Table 3-5. Microtopography ratings.[1]

Description	Rating
Less than 10 cm elevational difference between features on the RoW and similar features on the control; or similar number of features (rills, gullies, blowouts, roaches or subsidences)	0
Features on the RoW have 10 to 30 cm greater elevational difference than similar features on the control; or 50% more features on the RoW than on the control (e.g., rills, gullies, blowouts, roaches, etc.)	-1
Features on the RoW have 10 to 30 cm less elevational difference than similar features on the control; or 50% less features on the RoW than on the control (e.g., rills, gullies, blowouts, roaches, etc.)	+1
Features on the RoW have over 30 cm greater elevational difference than similar features on the control; or 2 times as many features on the RoW as on the control (e.g., rills, gullies, blowouts, roaches, etc.)	-2
Features on the RoW have over 30 cm less elevational difference than similar features on the control; or 2 times fewer features on the RoW as on the control (e.g., rills, gullies, blowouts, roaches, etc.)	+2

[1] This table does not apply to prescribed erosion control features.

3.3. SURFACE SOIL

The Surface Soil category contains three sub-categories; colour, surface aggregate size and strength, and texture. Each of the three sub-categories is described in detail in the following sub-sections. For the purpose of the Phase 1, surface soil is considered to be the near surface part of the soil profile that can be assessed without a major excavation. For orientation, it can be defined as the upper 2 to 4 cm of mineral material or, in the case of poorly-drained soils with more than 10 cm of peat, the upper 2 to 4 cm of organic material. A detailed examination of soil characteristics, including excavation, is the basis for Phase 2, if a Phase 2 is required.

3.3.1. Colour

Soil colour provides an estimate of soil organic matter content. In cases where material from the subsoil (e.g., C horizon) has been mixed with the A (surface) horizon, lower organic matter contents may impact soil productivity. The recommended procedure for determining soil colour is to collect a representative "handful" of soil from the surface of each of the RoW and Control, crush them by hand, dry the samples and then determine colour using the "Value" component of a Munsell Soil Color Chart.

In cases where the surface soil colour on the RoW and control are the same, a rating of "0" is assigned (Table 3-6). Soils that have a minor change in soil colour are assigned a rating of "+/- ". Soils that have a significant change in soil colour value are assigned a rating of "+/-2".

Table 3-6. Soil colour ratings.

Description	Rating
RoW and Control have the same colour	0
Soil colour 1 to <2 units of Value lighter on the RoW than on the Control	-1
Soil colour 1 to <2 units of Value darker on the RoW than on the Control	+1
Soil colour = >2 units of Value lighter on the RoW than on the Control	-2
Soil colour = > 2 units of Value darker on the RoW than on the Control	+2

3.3.2. Surface Aggregate Size and Strength

Surface aggregate size and strength on the reclaimed RoW provides a measure of the amount of admixing, compaction or poor reclamation procedures. **Soils are best compared when slightly moist or moist. Soil moisture conditions at the time of assessment should be recorded.** Alberta Environmental Protection (1995) defined three surface aggregate sizes for the assessment of reclaimed wellsites (Table 3-7). These three classes are equivalent to the medium (1 to 2 cm), coarse (2 to 5 cm) and very coarse (>5 cm) classes defined for soil structure in the *Canadian System of Soil Classification* (Soil Classification Working Group 1998).

Table 3-7. Surface aggregate sizes (Alberta Environmental Protection 1995).

Class	Aggregate size
1 (medium)	**less than 2 cm**
2 (coarse)	2 to 5 cm
3 (very coarse)	greater than 5 cm

* The **bold area** represents the "preferred" category.

Aggregate strength is normally estimated in terms of consistence (Table 3-8) as defined by the Expert Committee on Soil Survey (1983) in the *Canadian Soil Information System* (*CanSIS*) manual. Wet consistence relates essentially to clay content and is marginally related to strength. It is included here to help in those situations where there is no alternative to assessing this system in wet conditions. Again, it is stressed that moist conditions are the most suitable for estimating soil strength, while recognizing that, from a practical perspective, moist conditions are not always present.

Table 3-8. Aggregate strength (consistence) (Expert Committee on Soil Survey 1983).

Moisture Content	Consistence Class	Description
Wet[1]	Non-sticky	After release of pressure, no soil material adheres to the thumb and finger.
	Slightly sticky	After pressure has been applied, the soil material adheres to both the thumb and forefinger, but comes off one or the other cleanly. The soil is not appreciably stretched when the digits are separated.
	Sticky	After pressure has been applied, the soil material adheres strongly to both the thumb and forefinger and tends to stretch somewhat and pulls apart rather than pulling free from either digit.
	Very Sticky	After pressure has been applied, the soil material adheres strongly to both the thumb and forefinger and is decidedly stretched when they are separated.
Moist	Loose	The soil material is non-coherent.
	Very Friable	The soil material is crushed under very gentle pressure, but coheres when pressed together.
	Friable	The soil material is easily crushed under gentle to moderate pressure between the thumb and forefinger and coheres when pressed together.
	Firm	The soil material is crushed under moderate pressure between the thumb and forefinger, but resistance is distinctly noticeable.
	Very Firm	The soil material can be crushed between the thumb and forefinger, but strong pressure is required (force required is near the maximum that can be exerted between the extended thumb and forefinger for many people).
Dry	Loose	The soil material is non-coherent.
	Soft	The soil material is weakly resistant to pressure and fragile and breaks to a powder or individual grains under very slight pressure; the specimen fails under less than 8N of force (very gentle pressure).
	Slightly Hard	The soil material is weakly resistant to pressure and easily broken between the thumb and forefinger (the force corresponds to firm pressure between the extended thumb and forefinger of many people, but is significantly less than the maximum force that can be extended slowly).
	Hard	The soil is moderately resistant to pressure; it can be broken in the hands without difficulty, but considerable pressure is necessary to break it between the thumb and forefinger (force is near the maximum that can be exerted between the extended thumb and forefinger of most people).

Moisture Content	Consistence Class	Description
	Very Hard	The soil material is very resistant to pressure; it can be broken in the hands only with difficulty, and is not breakable between thumb and forefinger (force corresponds approximately to the force that can be applied slowly with a foot or by compression between two hands).
	Extremely Hard	The soil material is extremely resistant to pressure and cannot be broken in the hands (this is near the pressure of full body mass for many people).
	Rigid	The soil material cannot be broken except by extreme pressure.

[1] Wet consistence classes should be avoided if possible.

For comparing soils under different moisture conditions, an equivalency table was developed (Table 3-9). This table is derived from Table 3-8 (Expert Committee on Soil Survey, 1983). The comparison allows the soils analyst to compare consistency of soils under different moisture conditions.

Table 3-9. Consistence equivalence classes.

	Consistence		
	Wet[1]	Moist	Dry
Equivalent classes	non-sticky	loose	loose
	slightly sticky[2]	**very friable, friable**	**soft, slightly hard**
	sticky	firm	hard
	very sticky	very firm	very hard extremely hard rigid

[1] Wet consistence classes are to be avoided if possible.

[2] The **bold area** represents the "preferred" class. It should be used as a guide for assigning + or - ratings.

In cases where the surface aggregate size and strength on the RoW and control are the same, a rating of "0" is assigned. Soils that have a minor change in surface soil aggregate size or strength (one class difference as shown in Tables 3-7 and 3-9) are assigned a rating of "+/-1". Soils that have a significant change in surface soil aggregate size and strength (two classes difference as shown in Tables 3-7 and 3-9) are assigned a rating of "+/-2".

Table 3-10. Surface aggregate size and strength ratings.

Description	Rating
RoW and Control have the same aggregate size and strength	0
Change, between RoW and Control, of one aggregate size class (Table 3-7) in a direction away from the "preferred" class; or a change in one consistence class (Table 3-9) in a direction away from the "preferred" class.	-1
Change, between RoW and Control, of one aggregate size class (Table 3-7) in a direction towards the "preferred" class; or a change in one consistence class (Table 3-9) in a direction towards the "preferred" class.	+1
Change, between RoW and Control, of two aggregate size classes (Table 3-7) in a direction away from the "preferred" class; or a change in two consistence classes (Table 3-9) in a direction away from the "preferred" class.	-2
Change, between RoW and Control, of two aggregate size classes (Table 3-7) in a direction towards the "preferred" class; or a change of two consistence classes (Table 3-9) in a direction towards the "preferred" class.	+2

3.3.3. Texture

The soil texture on a reclaimed landscape should be the same as the texture of the undisturbed landscape. Changes to texture may result in a change in land capability (positive and negative) and in some cases may result in the need for special management practices.

The soil textural classes from the traditional soil texture triangle (Figure 3-1) were separated into six sub-groups and an organic class (Table 3-11), each with a distinctly different water holding capacity (Alberta Soil Series Working Group 1993).

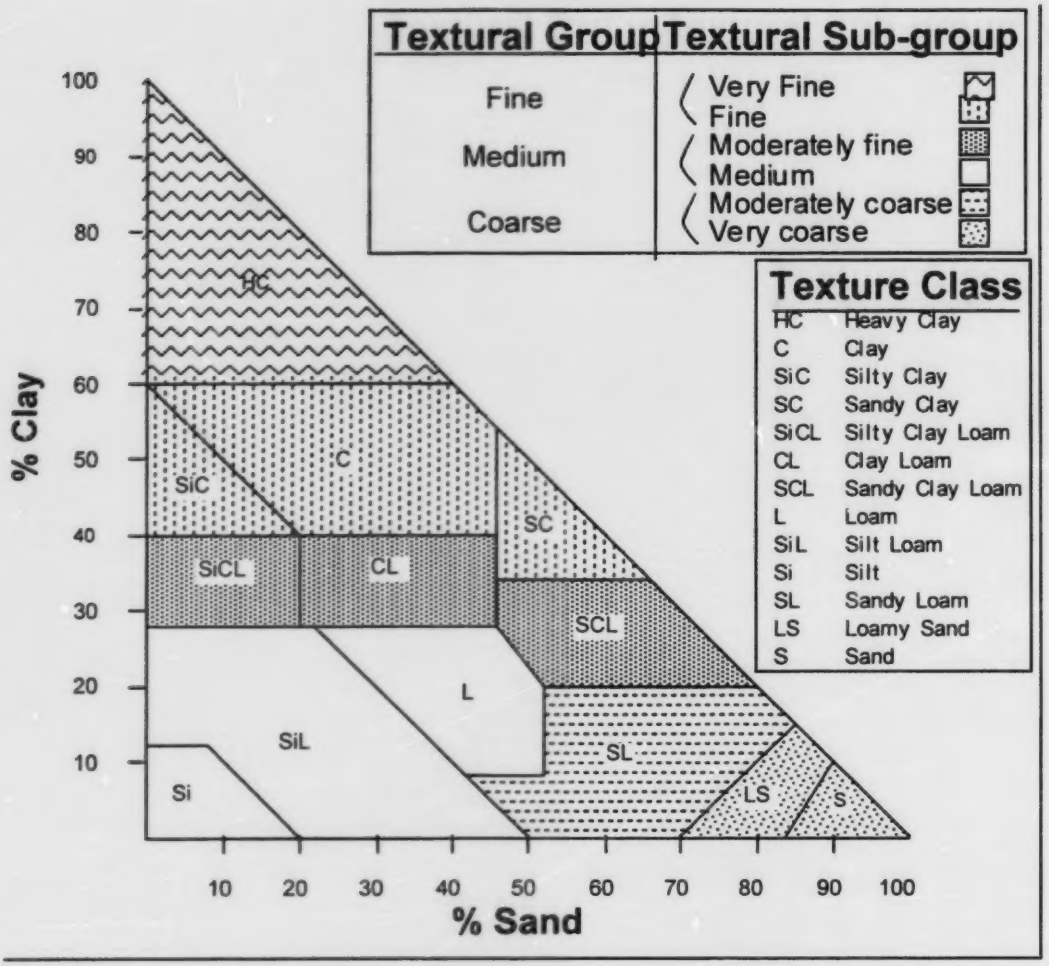


Figure 3-1. Soil texture sub-groups (Alberta Soil Series Working Group 1993).

Table 3-11. Soil texture classes and sub-groups (Alberta Soil Series Working Group 1993).

Textural Sub-Group	Soil Texture Classes
Very coarse	S, LS
Moderately coarse	SL
Medium[1]	**L, SiL, Si**
Moderately fine	SCL, CL, SiCL
Fine	HC, C, SiC, SC
Organic	-

[1] The **bold area** represents the "preferred" class. It should be used as a guide for assigning + or - rating.

In cases where the soil texture on the RoW and in the off-RoW control are in the same class, a rating of "0" is assigned. Soils that have a change of one textural sub-group are assigned a rating of "+/-1". Soils that have a change of two textural subgroups are assigned a rating of "+/-2" (Table 3-12).

Table 3-12. Surface texture subgroup ratings.

Description	Rating
RoW and Control have the same texture subgroup.	0
RoW differs from control by one textural subgroup in a direction away from the "preferred" class.	-1
RoW differs from control by one textural subgroup in a direction towards the "preferred" class.	+1
RoW differs from control by two textural subgroups in a direction away from the "preferred" class.	-2
RoW differs from control by two textural subgroups in a direction towards the "preferred" class.	+2

3.4. VEGETATION

The vegetation component contains two factors to be rated: growth characteristics and composition, both of which are rated on a qualitative scale. Each vegetation factor is described in detail in the following sub-sections. Ratings of the vegetation component are usually made on a visual (qualitative) basis, rather than gathering quantitative data.

It is not anticipated that collection of further vegetation detail will be necessary. However, if the assessor is uncertain about which class the observable contrasts between the RoW and controls are in, then a more specific vegetation assessment may be useful (see Section 3.5.3). Assessors may also want to use quadrats to calibrate visual estimates, prior to beginning assessments.

3.4.1. Plant Growth

Good vegetation growth on a reclaimed pipeline RoW is important for wind and water erosion control, post-reclamation land use (e.g., crops, grazing, wildlife habitat) and land management. Performance indicators that can be assessed, include: plant density, plant cover and plant height

and/or internode length, general health and plant distribution. The indicator(s) chosen should be appropriate for the vegetation type that is being assessed (see Sections 3.4.1.1 to 3.4.1.4) and its condition at the time of assessment.

Most assessments can be based on a qualitative, integrated view (of density, height, cover). However, where a contrast is evident, but the rating is not clear, **the most contrasting performance indicator(s)** (maximum of two) **should be used**. Comparisons are generally made to similar, representative, adjacent vegetation (controls) (Table 3-13). It is important to make comparisons when plants on the RoW and controls are at the same stage of growth. If this is not possible, or vegetation types are different, then growth characteristics of the vegetation on the RoW should be compared to similar vegetation a short distance away or to expected performance of the vegetation type for the geographic area.

Observations, but not ratings, on plant health and distribution are part of the vegetation assessment. Allowance for notes on these features has been incorporated in the data collection form (Appendix 3).

3.4.1.1. Plant Density

Density is defined as the number of plants per unit area (e.g., per square metre). Depending on the plant species, density may be the number of individual plants (crowns) or the number of plant stems or tillers. For some crops (e.g., field peas), it may be most appropriate to estimate the number of pods per plant. Plant density is a good indicator to use for most annual crops, young forage crops (1 to 2 years old where the plant canopy has not filled in yet), or cut/grazed forages and reforested areas. Density may also be used to determine the number of plants of a particular species per unit area.

3.4.1.2. Plant Cover

Plant cover is the proportion of ground within a two dimensional area that is covered by all living (including stems and leaves) and dead (litter) plant material that is produced naturally on a site, expressed as a percentage of the total area. Multiple layers of vegetation often result in cover values over 100%, however, absolute cover (compressing the vegetation layers) is used for this assessment. Litter can be calculated as a portion of the cover on RoW, up to amounts found on the controls. The presence of bare areas on the RoW may indicate potential soil problems, or it can be as simple as a miss in seeding. The intent of Phase 1 is to identify the extent but not the cause of bare areas. Plant cover assessment is the indicator usually used on mature forage stands and natural grasslands (e.g., prairie). Heavily grazed or cut stands are better assessed using density. Figure 3-2 provides some guidance for visual estimation of cover values for selected cover percentages. Section 3.5.2 provides assistance for assessing cover on native prairie and natural recovery (non-seeded) sites.

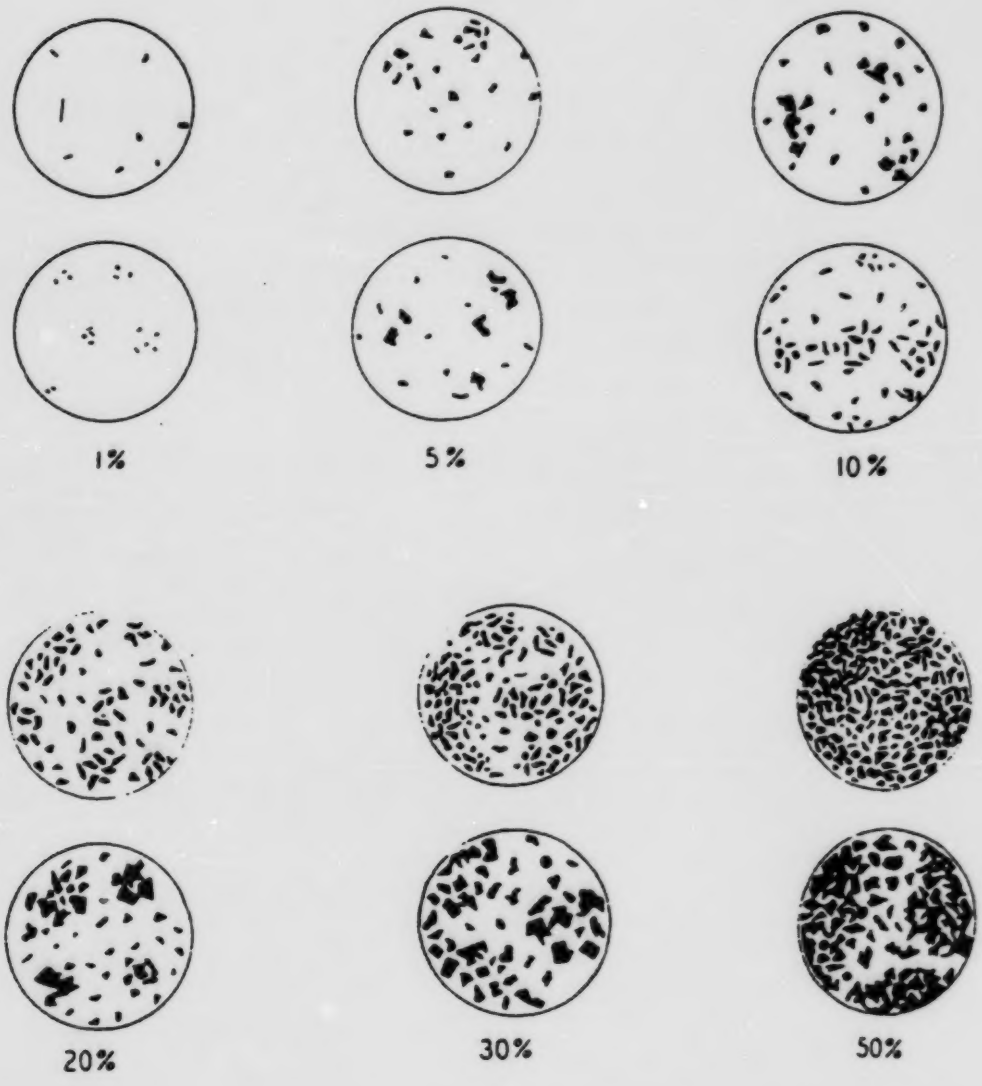


Figure 3-2 Guidance for visual estimation of percent cover.
(Adapted from Richard D. Terry and George V. Chilingar. Published by the Society of Economic Paleontology and Minerology in Journal of Sedimentary Petrology 25(3):229-234, September 1955.)

Plant distribution, the way that vegetation is dispersed on the RoW, should be similar to the distribution on controls. Assessment of plant distribution is not suitable where the vegetation on versus off the RoW is different. For crops that have been seeded, even distribution is expected. Uneven distribution where multiple plant types were seeded or bare areas, other than the spaces between seeded rows, may indicate soil problems or seeding error. On rangeland, where vegetation (e.g., shrubs), has been planted to simulate off-RoW conditions, an uneven, or clumped shrub distribution might be expected. Variations from expected plant distribution should be noted, but not rated.

3.4.1.3. Plant Height

Plant height is a good indicator to use for annual crops, seeded at the same time, or simple tame grass/legume forage stands. For some vegetation types (e.g., field peas), it may be more suitable to compare internode lengths (the length of stem between the points where leaves arise). Assessment of plant height/internode length is not suitable for comparisons between different vegetation types or to compare vegetation seeded at different times. Visible differences in plant height from controls can reflect differences in plant health due to disease or inadequate nutrition. Both these conditions can be caused by soil problems. It is also possible for vegetation on the RoW (seeded at the same time) to be taller than off-RoW. This often happens on Solonetzic soils where the restrictive soil horizon has been broken up by construction and plants have better access to moisture and nutrients.

3.4.1.4. Plant Health (Notes only)

Plant health refers to the general robustness, colour and productivity of vegetation on the reclaimed area when compared to controls. Any variations in plant health on vs. off the RoW should be recorded. Usually, one of the other vegetation factors will measure differences due to disease or poor plant nutrition. The exception may be a change in colour or evidence of disease that has not affected growth characteristics or plant composition (e.g., presence of ergot, potentially a hazard to livestock). A change in colour can indicate soil problems, such as water-logging. Where vegetation colour contrast is pronounced between the RoW and the control, the cause should be investigated further. It is important to keep the age and stage of growth of plants on and off the RoW in mind when assessing plant health. Differences in height, density and distribution may be due to differences in soil conditions but do not automatically mean that the plants are unhealthy.

Table 3-13. Ratings for variation in plant growth (density, cover or height).

Growth Characteristics		
Cultivated/Forage in Rotation (tame)	Rating	Rangeland (native and improved)*
RoW within 80% to 120% of the Control (within plus or minus 1/5 of the Control)	0	RoW within 65% to 135% of the Control value (within plus or minus 1/3 of the Control)
RoW within 65% to 80% of the Control (within 1/3 to 1/5 of the Control)	-1	RoW within 50% to 65% of the Control value (within 1/2 to 1/3 of the Control)
RoW within 120% to 135% of the Control (within 1-1/5 to 1-1/3 of the Control)	+1	RoW within 135% to 150% of the Control value (within 1-1/3 to 1-1/2 of the Control)
RoW less than 65% of the Control (less than 1/3 of the Control)	-2	RoW less than 50% of the Control value (less than 1/2 of the Control)
RoW greater than 135% of the Control (more than 1-1/3 times the Control)	+2	RoW greater than 150% of the Control value (more than 1-1/2 times the Control)

* See Section 3.5.3 for guidance on assessment of native prairie/natural recovery areas.

3.4.2. Species Composition

Plant composition refers to the different kinds, amounts and proportions of plants. These can be grasses, forbs, shrubs or trees. The rating in this section focuses on the presence of unsuitable plants, and the possible implications for land use and/or management.

3.4.2.1. Suitability of Composition

For the purposes of this assessment, **unsuitable plants** are viewed as a single entity and **include noxious and restricted weeds** (Section 3.5.1). These weeds are species recognized by provincial and local municipal governments as those requiring control or elimination (*Weed Control Act*). Assessors should contact municipalities/public land managers prior to assessment to determine the status of weeds/unsuitable plants in the area they are working in. Revegetation practitioners should also be aware of weed seed and other unsuitable plant seed contents in purchased seed (Alberta Agriculture, Food and Rural Development 2000).

Where noxious or restricted weeds/unsuitable plants are found both on and off the RoW, any differences on the RoW relative to controls should be observed and rated according to Table 3-14. Where no restricted or noxious weeds are found on the adjacent lands, none are acceptable on-RoW.

It is anticipated that in most circumstances the RoW will have been brought into land use in common with the adjacent land. Annual cultivation, forage rotation and pasture renovation will usually result in stands of equivalent species/type. Common exceptions include forages planted on the RoW in forested areas and non-native plants (e.g., crested wheat grass) planted on the RoW in prairie areas. Two concepts should be considered when determining the suitability of plant species:

- *Effective Productivity or Management Equivalence* is applicable primarily to perennial plant stands and considers whether the type or species of plants on the RoW are similar enough

that reliable productivity can be expected without extraordinary management being required on the RoW.

- *Interference* is applicable to both perennial and annual stands and relates to whether any species or type of plant are present only on the RoW, or are present in meaningfully increased numbers relative to the control. These plants create significant management difficulties within the land management unit. This may be a result of competitive interference (e.g., weeds) or management interference (e.g., excessive legume in pasture).

The suitability or unsuitability of plants on the RoW is based on the land use or ecological function of the revegetated area, and the accepted practice or agreement at the time of reclamation. If the latter is the case, the agreed standards or arrangements take precedence. In some circumstances there may be land use and revegetation goals that do not relate directly to the control conditions. For example, where RoWs are surrounded by stands of native vegetation, goals that include diversity, or perhaps evidence of native encroachment or seral progression, may have been negotiated. Where land use is not similar at the time of assessment, e.g., forage or pasture on-RoW versus forest off-RoW, it should be determined whether the plant composition on the RoW has any detrimental effect on the existing land use or management.

Crested wheat grass on the pipeline RoW is acceptable on publicly owned prairie only if:

- the RoW was reclaimed prior to September 1, 1992 when the *Minimum Disturbance Guidelines for Native Prairie* Informational Letter 92-12 was released by the Alberta Energy and Utilities Board and use of native grasses became a requirement; or
- the surrounding land is also planted with crested wheat grass (Native Plant Working Group 2001).

Some other non-native plants are considered unacceptable (unless agreed upon in writing) in native landscapes (Alberta Agriculture, Food and Rural Development 2000). Plant diversity (the presence of a number of plant species and plant forms) should be similar to or compatible with controls. Marked differences may signal soil problems. For example, predominance of clover where a grass/legume mix was seeded can indicate soil compaction problems. Predominance of salt-tolerant species can signal high salt content in soils.

Where occurrence of a particular, otherwise desirable, species in excessive dominance becomes a problem (e.g., too much legume in a grass stand), the same table could still apply, considering cover of the problem species alone.

Table 3-14. Ratings for variations in species composition.

Cultivated and Rangeland	Rating
Cover, type and extent of unsuitable plants on the RoW not distinctly different from the Control. RoW within 65% to 135% of the Control value for unsuitable species. (RoW within plus or minus 1/3 (35%) of the Control value for unsuitable species)	0
Cover, type and extent of unsuitable plants on the RoW contrasts with Control. RoW contains 135% to 150% of the Control value for unsuitable species. (1/2 to 1/3 more unsuitable species than on the Control)	-1
Cover, type and extent of unsuitable plants on the RoW contrasts with Control. RoW contains 35% to 50% of the Control value for unsuitable species (1/2 to 1/3 fewer unsuitable species than on the Control)	+1
Cover, type and extent of unsuitable plants on the RoW contrasts distinctly with Control. RoW contains 150% or more of the Control value for unsuitable species. (greater than 1 ½ times more unsuitable species than the Control)	-2
Cover, type and extent of unsuitable plants on the RoW contrasts distinctly with Control. RoW contains less than 50% of the Control value for unsuitable species. (less than ½ of the unsuitable species found on the Control)	+2

Notes: Species composition includes assessment of weeds.
When RoW value is less than or equal to 5% of the control value (occurs in lower control cover values) use 5%. For example, control value is 7%, then the calculated RoW value boundary between 0 and +/-1 = 2%. In this case, use 5% instead of 2% as it is very difficult to see a 2% difference.

3.5. ADDITIONAL INFORMATION

3.5.1. *Weed Control Act* (Alberta).

1) Restricted Weeds

(1) Red bartsia *Odontites serotina* L
(2) Diffuse knapweed *Centaurea diffusa* L
(3) Spotted knapweed *Centaurea maculosa* L
(4) Nodding thistle *Carduus nutans* L
(5) Eurasian water milfoil *Myriophyllum spicatum* L
(6) Dodder *Cuscuta spp.*
(7) Yellow star-thistle *Centaurea solstitialis* L

2) Noxious Weeds

(8) Russian knapweed *Centaurea repens* L
(9) Field bindweed *Convolvulus arvensis* L
(10) White cockle *Lychnis alba*
(11) Bladder campion *Silene cucubalus*
(12) Cleavers *Galium aparine* L & *Galium spurium*
(13) Hoary cress *Cardaria* spp.
(14) Knawel *Scleranthus annus* L
(15) Perennial sow thistle *Sonchus arvensis* L
(16) Cypress spurge *Euphorbia cyparissias* L
(17) Leafy spurge *Euphorbia esula* L
(18) Stork's bill *Erodium cicutarium* L
(19) Canada thistle *Cirsium arvense* L
(20) Toadflax *Linaria vulgaris*
(21) Persian darnel *Lolium persicum*
(22) Scentless chamomile *Matricaria maritima* L
(23) Common tansy *Tanacetum vulgare* L
(24) Blueweed *Echium vulgare* L
(25) Spreading dogbane *Apocynum androsaemifolium* L
(26) Field scabious *Knautia arvensis* (L) Duby
(27) Hound's tongue *Cynoglossum officinale* L
(28) Oxeye daisy *Chrysanthemum leucanthemum* L
(29) Tall buttercup *Ranunculus acris* L
(30) Purple loosestrife *Lythrum salicaria*

3) Nuisance Weeds

(31) Dalmatian toadflax *Linaria dalmatica* L
(a1) Wild radish *Raphanus raphanistrum* L
(32) Creeping bellflower *Campanula rapunculoides* L
(b1) Hedge bindweed *Convolvulus sepium* L
(33) Bluebur *Lappula echinata*
(34) Downy brome *Bromus tectorum*
(d1) Tartary buckwheat - *Fagopyrum tataricum*
(35) Wild buckwheat *Polygonum convolvulus*
(e1) Biennial campion *Silene cserei*
(36) Night-flowering catchfly *Silene noctiflora* L
(f1) Common chickweed *Stellaria media* L
(37) Field chickweed *Cerastium arvense* L
(g1) Mouse-eared chickweed *Cerastium vulgatum* L
(38) Rough cinquefoil *Potentilla norvegica* L
(h1) Cow cockle *Saponaria vaccaria* L
(39) Flixweed *Descurainia sophia* L
(i1) Green foxtail *Setaria viridis* L
(40) Quack grass *Agropyron repens* L
(j1) Narrow-leaved hawksbeard *Crepis tectorum* L
(41) Hemp nettle *Galeopsis tetrahit* L
(k1) Henbit *Lamium amplexicaule* L
(l) Lady's thumb *Polygonum persicaria* L
(m) Round-leaved mallow *Malva rotundifolia* L
(n) Ball mustard *Neslia paniculata*
(o) Dog mustard *Erucastrum gallicum*
(p) Green tansy mustard *Descurainia pinnata*
(q) Wild mustard *Sinapis arvensis* L
(r) Wormseed mustard *Erysimum cheiranthoides*
(s) Wild oats *Avena fatua* L
(t) Redroot pigweed *Amaranthus retroflexus* L
(u) Shepherd's purse *Capsella bursa-pastoris* L
(v) Annual sow thistle *Sonchus oleraceus* L
(w) Corn spurry *Spergula arvensis* L
(x) Stinkweed *Thlaspi arvense* L
(y) Russian thistle *Salsola pestifer*
(z) Dandelion *Taraxacum officinale*

3.5.2. Assessment of native plant stands and natural recovery (no seed) areas on public land.

Assessment of disturbed areas on natural landscapes (e.g., prairie) have shown that many years may pass following either seeding to native species or natural recovery (no seeding) before species composition, cover and density begin to approximate offsite conditions. For example, little club moss, a major constituent of many mixed grass prairie sites, can take longer than 50 years to re-establish. In these situations, it is not reasonable to compare the RoW to offsite controls. The following criteria should be used on RoW's in publicly owned natural landscapes:

- On prairie, native species must be seeded on public land, revegetated during or after September 1, 1992, or if required by disposition conditions or C&R approval.
- In forested areas, native species must be seeded on public land if required in the disposition conditions or in the C&R approval.
- Sufficient plant cover must be present to control erosion. Generally, a minimum of 50% live cover (absolute) and 10 to 20% naturally produced litter is sufficient. More cover (75% live with 10 to 20% naturally produced litter) is required on slopes. On older mixed grass prairie sites, where comparisons are being made to offsite, little club moss should be discounted from the control estimates of percent cover (unless it has also re-established onsite).
- On areas that were not seeded, the presence of minor amounts of transient, nuisance weeds such as flixweed is not a problem. These weeds can appear quickly following disturbance but usually disappear within 3 to 5 years, as the disturbed area fills in with native species.
- The presence of noxious or restricted weeds, or persistent annual weeds (e.g., downy brome) on the RoW are to be treated as in the Phase 1 discussion, i.e., no restricted or noxious weed species are acceptable on the RoW that are not found on adjacent land.

For more information about revegetation of natural landscapes please refer to *Native Plant Revegetation Guidelines for Alberta* (Native Plant Working Group 2001).

3.5.3. Guidelines for quantitative vegetation data collection.

1. Once potential "problem" units have been delineated, select inspection sites/transects that represent "typical/average" vegetation response across the map unit. It is very important that samples accurately represent the general vegetation quality and variability both on and off the RoW. The assessor should walk throughout the problem unit and control to get a feel for what a representative quadrat might look like.
2. Quadrats should be randomly located within representative areas.
3. The choice of quadrat size depends on the characteristics of the vegetation being assessed and convenience. Smaller quadrat sizes (e.g., 20 cm by 50 cm) are used for grasslands while larger quadrats (e.g., 4 m by 4 m or 10 m by 10 m) are more appropriate for shrubs (up to 3 m in height) and trees respectively. Rectangular or circular quadrats can be used.
4. Decide which of the vegetation subcategories require this detailed vegetation assessment. When assessing growth characteristics, the most contrasting single feature (e.g., cover, density, height, etc.), as compared to controls, should normally be chosen for assessment.

   For plant cover, absolute vegetation cover is estimated as the percentage of the ground within the quadrat that is covered by live vegetation (stems and leaves) or naturally occurring litter. Live cover should be visually compressed (top to bottom) before assigning a cover value (or values will add up to more than 100%). Litter, or dead vegetation covering the ground, should be assessed separately from live vegetation. Assessors can calibrate their assessments by comparing their estimates to figures that show what various percent cover values look like (see Figure 3-2).

   For plant density, the number of plants, tillers or fruiting bodies within each quadrat are counted.
5. Due to anticipated variability, a minimum of three observations (quadrats) is recommended within each of the control and the suspected contrasting area(s). It is suggested that a minimum of three quadrats be assessed and averaged for each selected vegetation parameter on the RoW and in the control. If vegetation on the trench seems different from the rest of the RoW, then a further three quadrats should be assessed on the trench. Average the observations within the control and the RoW and compare. If the range of the estimates in the control or in the contrasting area on the RoW exceeds one third of its average, make three additional observations and recalculate the average of the six observations.

   e.g., If stem density measurements are 30, 22 and 35; the average is 29

   The individual measurements are all within a third of 29 so no further observations would be required.
   If stem density measurements are 30, 25 and 47; the average is 34.
   47 is not within one third of 34 so another 3 observations are made.

Using the average values calculated for the controls and the RoW, rate each map unit using the tables in Phase 1.

4.0 PIPELINE RECLAMATION ASSESSMENT PHASE 2

4.1. INTRODUCTION

The Land Suitability Rating System (LSRS) (Agronomic Interpretations Working Group 1995) was tested for its applicability for pipeline reclamation assessment. It was concluded that, the LSRS could be readily adapted to address reclamation with the following modifications:

- the soils component of the LSRS should become the core of any detailed (Phase 2) reclamation assessment (it is the component that has undergone the most disturbance).
- the climate component is the same on- and off- RoW and can be reduced to a single index or constant.
- the landscape component is not required. The basis of this component is slope which is essentially negated by the use of appropriate control comparisons and, stoniness and microrelief are surface features that are addressed during Phase 1.

The soil component addresses water supplying capacity (in conjunction with climate), physical, chemical and inherent fertility limitations. These are basic considerations in the growth of all vegetation. The kind of vegetation grown (cereals, forages, trees) is mainly governed by climatic energy (heat units or frost free period). The generic soil factors are, for the most part, not plant specific. If the climate is not limiting, soils that can grow good wheat will also support good growth of hay and trees. Conversely, if it is limiting for one it will have limitations for all. There are some exceptions such as the effect of low pH on alfalfa or salinity on some trees, but these are not generally issues of concern across pipelines. If the rating is viewed as an index to compare on- and off-RoW conditions then minor variations for individual grains or forages (or trees) are not an issue. Very specific end uses, if encountered, can be handled by defining specific soil requirements.

It is suggested that any factors causing a greater than 20% change or 20 point deduction should be identified to help in directing remedial reclamation.

4.2. GENERAL APPROACH

4.2.1. Some Basic Attributes of Phase 2

The Phase 2 assessment is based on site specific data. The only exception is the climate (Precipitation minus Potential Evaporation or P-PE) index that can be assigned from using a general proxy (Table 4-32). Site selection should follow the general protocol outlined in the Pipeline Reclamation Assessment Manual (Section 2).

The following features are inherited from the LSRS:

- The system was designed as a field system. As such, it identifies commonly used field measurements, such as texture, structure and soil colour, that can be used as proxies for the basic, generic attributes used in the system description (see Table 4-33). Laboratory

analysis can be used to document problem or controversial situations but is not required for routine application of the system.

- The LSRS was developed to accommodate the wide range of climatic conditions across Canada. This gives it broad applicability but also results in extraneous tables or columns for any particular part of the country. Most of Alberta falls within the subhumid (P-PE lower than –200) category.

- There is considerable specificity built into the individual attribute ratings. This was done in response to the concern that a system that is too subjective does not give easily reproducible results. Increased detail is a trade-off with flexibility and speed of application. However, if it is important for many practitioners to have comparable results, then it is absolutely necessary to have well-defined, specific procedures. As the practical application of the system uses proxies, proper documentation is an important and integral part of the process.

- All the attribute ratings are based on continuous scales. This allows for extrapolation of data and means that there are no internal class boundary issues. It also facilitates computer programming aspects of the system.

It must be kept in mind that this is a field oriented procedure that relies heavily on the use of proxies for estimating basic soil attributes such as organic matter, water holding capacity, and bulk density (root restriction). The relationships have been established based on published research, unpublished but available, mainly local, research and expert experience. As more information becomes available these relationships could be modified so good field data documentation is quite important. Also, it should be noted that the final rating generated by Phase 2, which considers only the soils component, will not necessarily be the same as an LSRS rating. In the case of mineral soils, the soils component might be the same, however, for organic soils, even that rating will be different because the integrated temperature aspect has been removed.

4.2.2. Some Field Considerations

It is important that field data and observations be recorded for each transect at which a Phase 2 (soils) is conducted. The **Phase 2 Transect Soil Data Input Form** (Appendix 3) is provided to facilitate that activity. It is recommended that the assessor provide some indication of the kind of horizon/layer being identified. This may be done using standard horizon designations such as Ap, Ae, Bm, or Ck, or by terms such as topsoil, subsoil, subsoil2, or spoil. It is also recommended that some assessment of variation in soil attributes be documented at each site.

A second form, the **Phase 2 Transect Rating Form** (Appendix 3), is provided to facilitate the site rating and comparison across the transect. It is accepted practice to use averages at each site but not to average across map units which are the basis for the pipeline segment assessment.

Both forms must be attached to the reclamation certificate application.

4.2.2.1. Assessment of the surface horizon(s)/layers(s)

The surface horizon or layer is the most important part of the soil profile. Therefore, it is particularly important that its assessment be done in a proper and consistent manner.

For the purposes of this assessment, the 0 to 20 cm depth is used to represent the surface soil. As there are often contrasting features or horizons within that depth, including variations in depth of cultivation, the following guidelines are provided to assist the assessor.

- Field descriptions/documentation should include the recognition of any significantly different horizons or layers. That is, marked differences in organic matter, texture or structure.
- All features (organic matter, texture, etc.) should be averaged over the top 20 cm or to any layer less than 20 cm that severely impedes root growth.
- An exception is surface structure and consistence which should be assessed on the uppermost layer (e.g., a cultivated layer).
- It is only when a root restricting layer is present at less than 20 cm that the soil depth factor is used.

4.3. MINERAL SOILS - FACTORS AND RATINGS

Mineral soils are those having less than 40 cm of decomposed surface peat. Soils with deeper surface organic material are discussed in Section 4.4.

The rating for mineral soils is considered in four sections, the moisture supplying ability, surface factors (0 to 20 cm), subsurface factors (20 to 100 cm) and drainage. The emphasis is on the surface layer where seeds are planted and plants develop and extract nutrients. Other factors such as subsurface characteristics and drainage modify the basic rating. The factors in the basic rating are assessed point deductions while the modifiers, with the exception of subsurface texture, are assigned percentage reductions of the basic rating.

4.3.1. Water Supplying Ability (M)

4.3.1.1. Available water capacity/soil texture

The soil aspect being evaluated is its capacity to retain and supply water to plants. The available water holding capacity (AWHC), assessed as millimetres water per metre depth, may be estimated using soil texture, or data on clay and silt content (Table 4-1).

Table 4-1. Approximate relationship between available water holding capacity (AWHC) and texture or percent clay plus silt.

Texture	% Clay + Silt	AWHC (mm/m)
S	10	40
LS	20	60
SL	40	100
L	60	150
CL, SCL	70	170
SiL, Si	75	180
C, SC	80	190
SiCL	85	200
SiC	95	225
HC	95	225

It should be noted that:

- Depth of rooting zone, bulk density and structure, which all influence AWHC, are not taken into account in this simplified table. They are considered in other sections.
- No allowance is made for material coarser than 2mm, which has negligible water retention capacity. For soils with more than 5% by volume of coarse material, AWHC estimates should be reduced by the volume percentage of coarse material.
- High proportions of very fine sand and silt (50% or more) result in higher AWHC values than those that would be estimated from Table 4-1. For such soils, it is appropriate to increase the estimated AWHC by 20 mm/m.

4.3.1.2. The link to climate

The amount of water available to plants is a function of regional climate as well as soil factors. The climatic moisture factor (P-PE) was indexed assuming no soil limitation. Table 4-2 combines the climate and soil factors to give a composite rating for water supplying ability of a soil in a given climatic area. As indicated in the Table 4-1 notes, no allowance has been made for material larger than 2 mm that takes up space but does not hold water. Estimates of AWHC based on the proxies, should be reduced by the volume percentage of coarse material. For example, a SL with 40% by volume of gravel would have an estimated AWHC of 100 – (0.4 x 100) = 60 mm/m. Similar considerations should be used for the subsurface texture adjustment (Table 4-3).

Table 4-2. Point deductions for combinations of available water holding capacity (surface texture or % clay + silt) and the P-PE climate index.

Climate Index P-PE	% C+Si Texture[1] mm/m[2]	25	10 S 40	20 LS 60	40 SL 100	60 L 150	70 CL 170	75 SiL 180	80 C 190	85 SiCL 200	95 SiC 225	95 HC 225
0		40	15	0	0	0	0	0	0	0	0	0
-50		50	25	10	0	0	0	0	0	0	0	0
-100		60	35	20	10	0	0	0	0	0	0	0
-150		70	45	30	20	10	5	0	0	0	0	0
-200		80	55	40	30	20	15	10	10	10	10	10
-250		90	65	50	40	30	25	20	20	20	20	20
-300		95	75	60	50	40	35	30	30	30	30	30
-350		95	85	70	60	50	45	45	40	40	40	40
-400		95	90	80	70	60	55	55	50	50	50	50
-450		95	95	90	80	70	65	65	60	60	60	60

[1] CL includes SCL, SiL includes Si, C includes SC.
[2] Adjustments should be made for significant (> 5%) content of the > 2 mm fraction (gravel).

4.3.1.3. Subsurface texture adjustment of moisture supply

Table 4-2 assumes the common situation of a subsurface with the same or slightly finer texture than the surface (up to one class). Adjustments to the texture rating are made if the subsurface texture differs by more than one texture class from the surface texture (e.g., sandy loam over clay loam). These adjustments apply only to the soil component of the primary rating and are more sensitive to sandier textures (Table 4-3).

Table 4-3. Point adjustment to water supplying ability for subsurface texture.

Average subsurface texture[1] (% clay + silt)		Average surface texture (% clay + silt) S (10)	LS (20)	SL (40)	L (60)	CL-C (>70)
S	(10)	0	+5	+15	+25	+30
LS	(20)	-5	0	+5	+15	+20
SL	(40)	-15	-5	0	+5	+10
L	(60)	-25	-10	-5	0	+5
SiL-C	(>70)	-30	-20	-10	-5	0

[1] Average for 20 cm to 100 cm: assumed to account for 2/3 of the available moisture.

4.3.1.4. Water table adjustment of moisture supply

A further adjustment may be made to the moisture supplying ability based on the presence of a water table within the rooting zone. The effect of available subsurface water is to reduce any moisture deficit. The amount of reduction depends on the depth to the water table and the unsaturated hydraulic conductivity of the soil material, which commonly is related to texture (Table 4-4).

Table 4-4. Percent reduction of moisture deficit as a function of depth to water table during the growing season.

Depth of water table (cm)[1]	Drainage class	Texture of Subsurface		
		Coarse	Medium	Fine
0	very poor	100	100	100
25	poor	90	90	90
50	poor - imperfect	60	70	75
75	imperfect	20	40	50
100	imperfect - moderately well	0	10	20
125+	moderately well - well	0	0	0

[1] Highest 20 day average.

As an example of the application of this adjustment, consider a loamy sand in an area with a P-PE index of -250 and a water table at 75 cm (subsurface drain). The basic M factor would be a 50 point deduction with no adjustment for subsurface texture. The water table effect would reduce the deduction by 20% or 0.20 x 50 = 10 leaving a final deduction of 50 – 10 = 40 points.

4.3.2. Surface Factors

This section deals with the 0 to 20 cm depth. It is recommended that average conditions be determined and used for the surface layer, which will normally be 20 cm, or to down to a root restricting layer if it occurs at a depth of less than 20 cm from the surface.

In normal cultivated situations, averaging and rating are relatively straightforward. However, there may be situations where extreme conditions make averaging difficult. For example, some forested soils have extremely impoverished, leached, horizons with organic carbon contents of less than 0.5%. Also, some severely eroded soils or man-made soils may have extremely calcareous horizons with carbonate contents in excess of 40% near the surface. These situations could be accommodated under "depth of topsoil" where they can be treated as root restricting layers or, it is possible to rate the individual horizons and prorate by depth.

4.3.2.1. Surface structure and consistence: (D)

Soil structure, the size, shape and arrangement of aggregates and voids, affects infiltration and transmission of water, aeration and workability, root penetration and seedling emergence. It is commonly related to soil texture and organic matter content and to soil management. Associated physical properties are consistence and bulk density. General relationships among structure, consistence, texture, bulk density and limitations of soil as a medium for plant growth are described more fully in Section 4.5.1. The maximum deduction is set at 10 points because management can markedly modify surface soil features in cultivated soils (Table 4-5).

Table 4-5. Point deductions for surface soil structure and consistence.[1]

Structure	Consistence (moist/dry)	Point Deduction
Granular, subangular or fine blocky	friable/slightly hard	0
Blocky or platy single grained	firm/hard loose/loose	5
Massive	very firm/very hard	10

[1] For peaty surfaces see Section 4.4.2 on organic surface factors.

4.3.2.2. Organic matter content: (F)

Organic matter is a very important component of soils, contributing to the nutrient pool (mainly nitrogen), structure, workability and water holding capacity. Though there is no direct relationship between percentage of organic matter and soil quality, levels of organic matter below approximately 2% are generally associated with lowered soil quality for plant growth. The maximum point deduction for low organic matter is limited to 15 because appropriate management can increase organic matter content.

Organic content can be measured in the laboratory or it can be estimated by soil colour. The value component (the darkness or gray component) of the Munsell Soil Colour notation correlates quite well with percentage organic matter and can be used as a basis for estimating organic matter if other data are not available (Table 4-6).

Table 4-6. Deductions for surface organic carbon content.

Percent Organic carbon	Munsell colour value (dry)	Colour	Point deduction
> 6	2	black	0
4	3	black	0
3	4	dark brown or dark gray	2
2	5	brown; gray	5
1	6	gray	10
< 1	7	light gray	15

[1] The surface layer considered is the top 20 cm of mineral soil; in many cases this is the cultivated layer. In uncultivated soils, or when cultivation depth is less than 20 cm, the average organic matter content of the top 20 cm of mineral material should be estimated. If the surface layer is less than 5 cm thick, the organic matter content (or colour) of the underlying layer should be used as a basis for the point deduction.

4.3.2.3. Depth of topsoil (Ah or Ap horizon): (E)

The relatively dark coloured surface horizon (Ah undisturbed, Ap cultivated) usually contains more organic matter and has a more favourable structure than the subsurface. The depth at which the subsoil occurs and the nature of the subsoil are related to plant growth and ease of management. The main concern is the presence of a root restricting layer within the top 20 cm.

Two situations can be recognized:

- a dense, very firm or hard horizon with a bulk density > 1.55.
  – some Bt, Bnt, Bx, Cx horizons or compacted layers
- extreme conditions such as very low OC content (<0.5%) or very high carbonate or salt content.
  – some Ae or C horizons or constructed layers

The latter should only be used where the extreme conditions extend beyond 20 cm. That is, they would not be destroyed by mixing the top 20 cm.

Deductions are made **only** if the subsoil is restricting to root growth. A non-restricting subsoil within 20 cm of the surface will already have incurred deductions for organic matter content and structure. Point deductions for depth of topsoil are given in Table 4-7.

Table 4-7. Point deduction for depth of topsoil (Ap/Ah horizon).

Type of root restricting layer	Depth (cm) of topsoil (Ah/Ap horizon)[1]				
	20	15	10	5	0
very firm, hard, massive, very calcareous or very acidic (Bt, Bnt, Bx or Cca horizon[2] or strongly compacted layer)	0	5	10	15	20

[1] Depth to a root restricting layer.
For Ah horizons (uncultivated soils) less than 5 cm thick and for Ap horizon (cultivated soils) with Munsell values of 6 or lighter, the 0 cm depth column should be used.

[2] Standard soil horizon designations.

4.3.2.4. Soil reaction: (V)

A high pH or alkaline condition can also affect plant response but this situation is usually associated with saline or sodic conditions (Sections 4.3.2.5 on "salinity" and 4.3.2.6 on "sodicity"). Values above 8.5 occur only if there is a relatively high sodium content associated with a generally low lime content. This situation is rare in Canada under natural conditions. If a deduction is made for salinity or sodicity, no deduction is made for high pH values (it would be a double penalty).

There are several common methods for determining pH: saturated paste (water), 1:2 soil-water suspension and 1:2 soil - 0.01 M $CaCl_2$. Compared to the saturated paste, the $CaCl_2$ pH is usually about 1/2 unit lower in value and the 1:2 water value slightly higher. It should be kept in mind that seasonal variation in soil pH is often in the order of 1/2 unit.

Deductions associated with surface soil pH are shown in Table 4-8.

Table 4-8. Point deduction for surface soil pH as measured in a saturated paste.[1]

Soil pH	Point deduction
9.0	60
8.5	20
8.0	5
6.0-7.5	0
5.5	5
5.0	15
4.5	30
4.0	55
3.5	80

[1] Add 0.5 units to pH values measured in 0.01 M $CaCl_2$.

4.3.2.5. Salinity: (N)

Salinity refers to the presence of excessive amounts of soluble salts such as magnesium sulphate. Salinity affects crop growth in two ways. There are chemical effects, but the presence of salts also makes it more difficult for plants to take up water.

Salinity, expressed in terms of electrical conductivity (EC), can be measured in the field or laboratory, or it can be estimated from soil and vegetation characteristics. Plants vary appreciably in salt tolerance, but effects become noticeable at an EC of about 4 dS/m and moderate to severe by an EC of 8 dS/m. There is very little plant growth at an EC of 16 dS/m (Table 4-9).

Table 4-9. Point deduction for surface soil salinity.

Salinity[1] (dS/m)	Common features	Point deduction
2	no apparent signs may affect sensitive crops	0
4	presence of foxtail some white specks on soil surface crop growth affected to some extent	20
8	plants restricted to salt tolerant species (e.g., Kochia) white salt crusts common crops strongly affected	50
16	plants restricted to species such as red samphire salt crust and salts throughout profile little or no crop growth	90

[1] Measured in extract of water-saturated paste.

4.3.2.6. Sodicity: (Y)

This factor is used only for reclaimed RoW soils.

As the percentage of sodium on the soil exchange complex increases over about 15% (usually associated with a pH over 8.5) the stability of soil aggregates decreases markedly. The finer soil particles, clays and organic matter, become dispersed resulting in adverse physical conditions, i.e., massive and sticky when wet and extremely hard when dry. This factor is not used if the surface texture is coarser than loam (at soil clay contents below approximately 15%, the usefulness of this soil factor proxy becomes problematic).

Deductions indicating the effect of SAR are given in Table 4-10. If this table is used, no deduction is made for pH.

Table 4-10. Point deduction for surface soil sodicity and saturation percentage.[1]

Sodicity (SAR)[2]	Saturation percentage (Sat %)	Point deduction
4	60	0
8	80	10
12	120	30
16	160	50
20	>160	80

[1] Used for reclaimed RoW soils only. If points are deducted for SAR, do not deduct for pH and salinity.

[2] SAR = Sodium Adsorption Ratio.

4.3.2.7. Organic (peaty) surface: (O)

Organic surface horizons will not likely be present on reconstructed soils but occur in undisturbed portions of a transect. Organic surfaces present special management problems which are related to seed bed preparation and coldness. The degree of decomposition of the peat and the depth of organic material are the rated parameters. The well decomposed, dark coloured, humic, sedge peats which are generally well compacted and have a granular structure are the most favourable. The least favourable are the light coloured, fibric, moss peats that are quite porous. Mesic materials have characteristics between the other two.

Peaty (surface peat) mineral soils grade to Organic soils (deep peat) when the depth of peat exceeds 40 cm (60 cm if all fibric). However, depths are not always easy to establish particularly when cultivation results in an immediate compaction of the deposit. In general mesic peats will compact about 30% and fibric peats about 40%. Therefore, the maximum depth of cultivated or compact peat to be considered in this section is about 30 cm (40 x 0.7, 50 x 0.6). Anything deeper is discussed under Organic soils (Section 4.4).

Deductions associated with this factor are shown in Table 4.11.

Table 4-11. Point deductions for organic surfaces.[1]

Depth of Peat (cm)[2]		Degree of decomposition	General structure	General consistence	Point deduction
non-compact	compact				
15	15	humic	compact	friable	5
20	15	mesic			5
25	15	fibric	spongy	fibrous	10
30	30	humic	compact	friable	10
40	30	mesic			15
50	30	fibric	spongy	fibrous	20

[1] If deductions are made for an organic surface, the mineral soil ratings for texture, structure and organic matter are not used.

[2] If the depth of peat is less than 10 cm the soil should be rated as a mineral soil.

4.3.3. Subsurface Factors

4.3.3.1. Subsurface structure and consistence: (D)

Subsurface soil structure, consistence and density affect root penetration and therefore the availability of water and nutrients to plants. The effects of those three factors in limiting plant growth are also related to texture. For example, a bulk density of 1.5 to 1.6 Mg/m^3 may be favourable for plant growth in sand but such a bulk density in clay is likely to be associated with massive material that is waterlogged when wet, very hard when dry, and highly unfavourable as a rooting medium for most plants.

The actual impact on plant growth of a layer that restricts root penetration depends upon the depth at which the layer occurs and also on the regional climate. Therefore, the primary deduction (Table 4-12) is modified by depth and climate factors (Table 4-13) to give a final point rating for impeding subsurface layers. For example, consider a soil with a clay loam layer of bulk density of 1.6 Mg/m^3 at a depth of 60 cm within the <-200 P-PE zone. The deduction for the impeding subsurface layer would be 30 (from Table 4-12) x 60% (from Table 4-13) = 18%.

Bulk density may be estimated from structure and texture observations (Section 4.5.1.1, Tables 4-32, 4-33, and 4-34).

Table 4-12. Percent deduction for combinations of bulk density and texture (or % clay) of impeding subsurface layer.[1]

Bulk density	% Clay texture	0 S	10 SL	20 L	35 CL	50 SiC	70 HC
1.25		0	0	0	0	0	0
1.30		0	0	0	0	0	0
1.35		0	0	0	0	0	5
1.40		0	0	0	0	5	15
1.45		0	0	0	5	15	25
1.50		0	0	5	15	25	35
1.55		0	5	10	20	35	45
1.60		5	15	20	30	45	55
1.70		25	30	40	50	60	80
1.80		45	50	60	70	85	-
1.90		65	75	85	90	-	-
2.00[2]		90	90	90	-	-	-
Rock		90					

[1] The effect of bulk density on root growth compiled from the literature.

[2] A paralithic layer (rippable bedrock) is considered to have a bulk density of 2.00.

Table 4-13. Percent depth modifications for impeding subsurface layers.

Depth (cm) to impeding layer	Percent depth modification
20	100
40	80
60	60
80	35
100	10
120	0

4.3.3.2. Non-conforming (geologic) layer

A nonconforming layer indicates a distinct change in material. It is a geologic rather than a pedologic feature. This factor, like structure, consistence and bulk density, is important in terms of water movement and retention, and root penetration. This factor has been restricted to a strongly contrasting situation, namely: gravel and sand underneath loam or finer. The following table indicates the percent deduction for contrasting subsurface texture.

Do not use this table if Tables 4-12 and 4-13 have already been used.

Table 4-14. Percent deductions for depth to non-conforming subsurface.

Depth to contact (cm)	Percent deduction
20	30
50	0
100	0

4.3.3.3. Subsurface reaction: (V)

Subsurface pH levels have the same kind of effects on nutrient availability and plant growth as those in the surface layer. Since alkaline reactions are generally only a problem when associated with salinity and sodicity they are dealt with in those sections, and this section considers only acidic reactions. It was felt that the 20 to 60 cm depth was the most critical and should serve as the basis for this factor. The impact of specific pH levels in the subsurface would be less severe than in the surface layer. Points are deducted for subsurface acidity (Table 4-15) only if they are greater than the deduction for surface acidity.

Table 4-15. Percent deduction for subsurface acidity.[1]

Soil pH[2]	Percent deduction
6.0-7.5	0
5.5	2
5.0	5
5.5	2
4.5	15
4.0	30
3.5	55

[1] This deduction is made only if it exceeds those for surface acidity (Table 4-8) and sodicity (Table 4-10).

[2] Measured in saturated paste. Add 0.5 unit to pH values measured in 0.01 M $CaCl_2$.

4.3.3.4. Subsurface salinity: (N)

A subsurface salinity deduction (Table 4-16) should be made only if it is greater than the deduction for salinity of the surface.

Table 4-16. Percent deduction for subsurface salinity.[1]

EC (dS/m)[2]	Percent deduction
< 4	0
4	10
8	20
12	40
16	70

[1] This deduction is made only if it exceeds that for surface salinity (Table 4-9).

[2] Measured in saturation extract.

4.3.3.5. Subsurface sodicity: (Y)

This factor is used only for reclaimed RoW soils.

Subsurface sodicity (as measured by SAR) is evaluated only if it is more limiting than the surface sodicity. If point deductions for subsurface sodicity are equal to or less than the point deductions for surface sodicity, the subsurface is not evaluated. As with the surface evaluation, this factor should not be used for soils with a texture coarser than loam. The average SAR for the 20 to 100 cm depth is considered in determining subsurface SAR.

To avoid excess deduction of points for related soil parameters, point deductions are made for SAR only if the limitation is more severe than the subsurface salinity limitation (Section 4.3.2.5). Table 4-17 indicates the percent deductions for the various sodicity (SAR) classes.

Table 4-17. Percent deduction for subsurface sodicity.[1]

Sodicity (SAR)[2]	Saturation percent (Sat %)	Percent deduction
4	60	0
8	80	10
12	120	30
16	160	50
20	>160	80

[1] If points are deducted for SAR do not also deduct for pH and salinity.

[2] SAR = Sodium Adsorption Ratio (see Glossary of Terms for definition).

4.3.4. Drainage (W)

Drainage as used in this system refers to site specific evaluations of (mainly) internal components which include both the water table and hydraulic conductivity (permeability). The rating is based principally on management or trafficability considerations (i.e., on the ability to work the land on a timely annual basis). The water supplying or plant growth component is dealt with in Section 4.3.1.

Drainage is considered as a modifier to the surface rating and is managed as a percent deduction.

There are two main considerations:

- The depth of the water table during the critical (usually) spring period. This is one of the most difficult evaluations in the system because of the variation with time.

  - The depth used should represent a 20 day average covering the most critical period recognizing that there may be periods of higher water table and that it will usually be much lower later in the growing season.
  - Perched water tables, particularly common in areas with dense subsoils and high precipitation, should also be considered in this assessment.

- The saturated hydraulic conductivity of the most limiting layer.
  - This reflects the ability of the soil to drain without a water table constraint.
  - Three general categories are recognized: rapid, >15 cm/hr; moderate, 0.5 to 15 cm/hr and slow, <0.5 cm/hr.

It is not always practical to make the physical measurements necessary to characterize the water regime, but there are a number of soil and vegetation features, in undisturbed conditions, that can be used to estimate the drainage factor (highest 20-day average).

- Water table at or near the surface. Very poorly drained; Gleysolic soils, often Rego or Rego Humic subgroups. Strongly reduced (blue-grey) in native state.
- Water table at 25 to 50 cm. Poorly drained. Gleysolic soils, usually Orthic and Luvic subgroups. Prominent (reddish) mottles in the 0 to 50 cm zone.
- Water table at 75 cm. Imperfectly drained. Usually Gleyed subgroups with prominent mottles at the 50 to 100 cm. This also applies to a perched water table situation.
- Water table >100 cm. Moderately well and well drained soils. Mottling faint or absent.

In addition:

- Tile drains are assumed to establish a water table at 75 cm.
- Hydraulic conductivity or permeability can be estimated from soil structure or from texture with: sands = rapid; loams = moderate, and clays = slow. This is generally true, but there are many well structured clays with moderate permeability and compact, dense loams with very slow permeability so knowledge of soil structure is important.
- Soil features respond slowly to changes in the drainage regime, particularly in slowly permeable materials, and sandy soils often display prominent mottles even if imperfectly drained. Therefore, soil features alone can be misleading in artificial or managed systems. In these cases the continuing limitation should be assessed in terms of cultivation experience such as number of years out of 10 when seeding was possible.

Ratings of the drainage factor reflect the above considerations and the experience of pedologists and agronomists across Canada.

Table 4-18. Percent deductions for soil moisture regime.

Depth to water table (cm)[1]	Usual Drainage Class	Hydraulic Conductivity (cm/h)		
		low (<0.5)	medium (0.5 to 15)	high (>15)
Standing water	-	100	100	100
0	very poor	90	90	90
25	poor	70	65	60
50	poor – imperfect	50	40	30
75	imperfect	30	15	10
100	imperfect - moderately well	10	0	0
> 100	moderately well – well	0	0	0

[1] Highest 20-day average in growing season.

Table 4-19. Percent deduction for soil moisture regime using a management proxy.[1]

Limited seeding (years out of 10)	Percent Deduction
10	100
8	80
5	50
2	20
0	0

[1] This table may be used if information on water table is not available.

4.3.5. Calculation of the Mineral Soil Rating (S)

The **Phase 2 Transect Rating Form** is used to calculate the mineral soil rating. The form must be attached to the reclamation certificate application.

The following steps are suggested:

1. Examine the soil and fill in the "value" for each parameter. For example: surface texture, sandy loam; OM content (colour), dark gray; etc.
2. Using Table 4-2 and values for P-PE and surface texture, determine the available water holding capacity deduction (The value of P-PE can be estimated from Table 4-32).
3. Determine the subsurface texture and use Table 4-3 to assign the appropriate adjustment. Add the deductions from steps 2 and 3 to obtain the texture deduction.
4. Determine the appropriate percentage adjustment for water table from Table 4-4.
5. Calculate the moisture deduction points.
6. Record the surface structure/consistence; note and record the appropriate point deduction from Table 4-5.
7. Similarly record the values for the other surface properties listed and use Tables 4-6 to 4-11 to determine the respective point deductions.

Deductions are made for only the most limiting of reaction, salinity and sodicity.

8. Add the points deducted for surface factors to the deduction for moisture factor and subtract the total from 100 to give an Interim Soil Rating.

9. Record values for the subsurface properties listed and assign percentage deductions using Tables 4-12 to 4-17. Follow the rules given in the text. For example, deduct points for only one of surface and subsurface reaction (the one giving the greater deduction).

10. Add the percent deduction for applicable subsurface factors to give the total percentage deduction. Calculate that percentage of the Interim Soil Rating to obtain the deduction for subsurface features.
    - Subtract from the Interim Soil Rating in step 8 to give the Basic Soil Rating.

11. Estimate depth to water table in the spring (if available) or drainage class and use Tables 4-18 to 4-21, as appropriate, to determine the percentage reduction for drainage. Calculate that percentage of the Basic Soil Rating to get the drainage deduction.

12. Subtract the drainage deduction from the Basic Rating to give a final soil rating.

13. You may at this stage also identify any factors which resulted in a greater than 20 point or 20% deduction and assign the appropriate subclass symbol.
    - An example of a completed soil rating is provided in Appendix 2.

4.4. ORGANIC SOILS - FACTORS AND RATINGS

Organic soils are those which have greater than 40 cm of peat (greater than 60 cm if fluffy fibric peat) (Expert Committee on Soil Survey 1983). Organic soils having permafrost (Organic Cryosols) are treated as organic soils for the purpose of this rating.

The rating is based on the same concepts and is an extension of the mineral soil rating with appropriate modifications. It considers moisture supplying ability, surface factors (0 to 40 cm), subsurface factors (40 to 120 cm) and drainage. Again, the emphasis is on the surface horizon. There are some differences, however, both in the specific factors considered in the soil components and in the relative importance of the components. Nutrient supply is a special problem in most organic soils and so is included. As well, reclaimed organic soils continue to subside at about 1 to 3 cm per year, hence, the depth and nature of the underlying mineral material affect the continued productivity of the organic soils and therefore, are modifying factors in determining suitability.

The organic equivalent to particle size distribution is fibre content and the "texture" of peats is expressed as fibric (a lot of fibre), mesic or humic (very little fibre). In general, a very fibric material with large air spaces acts very much like a coarse sand and the low fibre peats act somewhat like clays with respect to water movement. Those peats with no fibre often pose special management problems in terms of both water movement and mechanical issues. The basic correlations between fibre content, bulk density and water aspects as used in this procedure are given in Section 4.5 (Table 4-36).

A characteristic of peats is the compaction which takes place under drainage disturbance or cultivation. This makes depth comparisons based on undeveloped conditions somewhat difficult. For consistency, it is suggested that a "compacted" depth be used as a standard reference. Table 4-20 presents some general guidelines for assessing settlement of peat materials.

Table 4-20. Approximate settlement of different peat materials.

Relative density (Mg/m^3)	Degree of decomposition (% fibre)	Approximate settlement
very loose (< 0.07)	Fibric (>60%)	40 %
loose (0.07 to 0.10)	Fibric – Mesic (40% to 60%)	30 %
rather dense (0.10 to 0.18)	Mesic (20% to 40%)	20 %
dense (>0.18)	Humic (<20%)	15 %

4.4.1. Water Supplying Ability (M)

All peats hold a large amount of water at saturation but the availability of that water varies markedly with material characteristics. The low density, fibric types, with large pore spaces, drain very quickly under gravity and can become droughty under conditions of climatic moisture deficit. The denser, humic peats, on the other hand, drain very slowly and are subject to waterlogging under very humid conditions.

Point deductions for this factor are presented in Table 4-21.

Table 4-21. Point deductions for combinations of water holding capacity and regional climate.

	Surface		Fibric		Mesic			Humic	
Climate	Fibre content[1]	80	60	40	30	20	10	5	0
	von Post scale	1 2	3	4	5	6	7	8 9	10
P - PE	Bulk density[2]	0.04	0.07	0.10	0.13	0.16	0.18	0.20	0.22
-250		40	30	20	15	10	5	0	0
-200		35	25	15	10	5	0	0	0
-150		30	20	10	5	0	0	0	0
-100		25	15	5	0	0	0	0	0
-50		20	10	0	0	0	0	0	0
0		15	5	0	0	0	0	0	0
+50		0	0	0	0	0	0	0	0

[1] % rubbed fibre >0.15 mm.

[2] bulk density in Mg/m^3.

Drainage or depth to water table is nearly always a factor in managing organic soils. This influence also varies with density (porosity) of material (Table 4-22).

Table 4-22. Water table adjustment (% reduction) to water supplying.

Depth to water table (cm)	Subsurface Fibre content[1]	Fibric 80	60	40	Mesic 30	20	10	Humic 5	0
	von Post scale	1 2	3	4	5	6	7	8 9	10
	Bulk density[2]	0.04	0.07	0.10	0.13	0.16	0.18	0.20	0.22
0		100	100	100	100	100	100	100	100
25		90	90	95	95	95	100	100	100
50		60	70	80	80	85	90	95	95
75		20	30	40	50	60	70	80	90
100		0	0	10	20	30	45	60	70
125		0	0	0	0	10	20	30	50

[1] % rubbed fibre >0.15 mm.

[2] bulk density in Mg/m^3.

4.4.2. Surface Factors

The top 40 cm of compacted peat is considered for the base rating. This is 20 cm more than for mineral soils in recognition of the settlement and mineralization that takes place in organic soils. Even at a rate of 1 cm a year the modification is substantial. Three factors are rated for their contribution to seed establishment, crop growth and management. These are structure and consistence (fibre content), reaction and nutrient status, and salinity.

4.4.2.1. Surface structure and consistence: (B) (degree of decomposition)

The preparation of a proper seedbed is a major management concern at extremes in density/fibre content. Loose packing results in poor seed to soil contact and soils with no fibre are often amorphous and can seal or crust. Workability is also related to climate (Table 4-23).

Table 4-23. Point deductions for surface structure (bulk density) of organic soils.

Climate	Surface Fibre content[1]	Fibric 80	60	40	Mesic 30	20	10	Humic 5	0
	von Post scale	1 2	3	4	5	6	7	8 9	10
P - PE	Bulk density[2]	0.04	0.07	0.10	0.13	0.16	0.18	0.20	0.22
-250		60	50	40	35	30	25	20	15
-200		50	40	30	25	20	15	15	20
-150		40	30	20	15	10	10	15	25
-100		30	25	15	10	5	10	20	30
-50		25	15	10	5	5	10	25	35
0		20	10	5	0	5	15	30	40
+50		15	5	0	5	15	30	40	50

[1] % rubbed fibre >0.15 mm.

[2] bulk density in Mg/m^3.

4.4.2.2. Surface reaction and nutrient status: (V)

Organic soils can have a wide range of nutrient levels that are correlated to a large degree with the source of water. Those areas receiving water mainly from surrounding mineral soils or from groundwater usually have a near neutral pH and relatively higher nutrient contents (eutrophic). Those areas where the water at the surface of the organic deposit is primarily from precipitation are usually more acidic and are generally nutrient poor (oligotrophic). In

nearly all cases organic soils have special fertilizer requirements. Potassium need is universal and micronutrient deficiencies are common, particularly in the more acidic environments.

There is a correlation between fertility and acidity but it is not confined to a single effect. Another aspect of fertility revolves around the relationship between nutrient content, origin of material and degree of decomposition. Again it is not a simple correlation but one which also involves water source and pH. Very broadly speaking, the raw sphagnum peats have high fibre content, high C:N ratios, low pH, and low nutrient contents while the moderately decomposed sedge peats commonly have low fibre contents, lower C:N ratios, a more neutral pH and a better supply of nutrients. Point deductions for these factors are presented in Table 4-24.

Table 4-24. Point deductions for reaction/nutrient status.

Reaction	Surface	Fibric		Mesic			Humic	
	Fibre content[1]	80	60	40	30	20	10	5	0
	von Post scale	1 2	3	4	5	6	7	8 9	10
(pH)	Bulk density[2]	0.04	0.07	0.10	0.13	0.16	0.18	0.20	0.22
>7.5		See Section 4.4.2.3 on surface salinity							
7.5		50		35		25		15	
7.0		45		30		20		10	
6.5		40		30		20		10	
6.0		40		30		20		10	
5.5		40		30		20		10	
5.0		45		35		25		15	
4.5		50		40		30		20	
4.0		55		45		35		30	
3.5		60		50		45		40	
3.0		70		60		55		50	

[1] % rubbed fibre >0.15 mm.

[2] bulk density in Mg/m^3.

4.4.2.3. Surface salinity: (N)

Saline organic soils are rare but may occur. The same limitations would apply as for mineral soils (Table 4-25).

Table 4-25. Point deductions for salinity.

salinity dS/m[1]	point deduction
2	0
4	20
8	50
16	75

[1] measured in saturated paste.

4.4.3. Subsurface Factors

Subsurface factors are considered as modifiers of the surface (base) rating and as such are managed as percentage reductions. The depth is taken up to a maximum of 120 cm. This is 20 cm greater than for mineral soils because of the deeper surface horizon defined to recognize subsidence in these soils. Four factors are recognized in this category: subsurface structure and consistence (degree of decomposition), depth of deposit and kind of substrate, reaction and nutrient status, and salinity.

4.4.3.1. Subsurface structure and consistence: (B) (degree of decomposition)

Table 4-26 is a general index to reflect the kind of material and its state of decomposition (fibre content). It is based on an average for the 40 to 120 cm depth or to a shallower strongly contrasting material such as mineral soil or a sedimentary peat layer more than 10 cm thick.

Table 4-26. Percent deduction for subsurface structure/bulk density of organic soils.

Surface	Fibric			Mesic			Humic	
Fibre content[1]	80	60	40	30	20	10	5	0
von Post scale	1 2	3	4	5	6	7	8 9	10
Bulk density[2]	0.04	0.07	0.10	0.13	0.16	0.18	0.20	0.22
Percent deduction	20	10	0	0	0	5	10	20

[1] % rubbed fibre >0.15 mm.

[2] bulk density in Mg/m^3.

4.4.3.2. Depth of deposit and kind of substrate: (G)

The depth to, and kind of, substrate affect a number of aspects in the management of organic soils ranging from water control to nutrition to long term management and sustainability (Table 4-27).

Table 4-27. Percent deduction for contrasting subsurface layers.

Kind of layer[1]	Depth (cm)		
	40	80	120
sandy	10	10	0
loamy	0	0	0
clayey	20	10	0
gravel	70	40	10
gyttja	80	50	10
bedrock	90	60	30

[1] Includes sedimentary peat and coprogenous earth.

4.4.3.3. Subsurface reaction and nutrient status: (V)

Subsurface acidity, while not as critical as surface considerations, can still affect plant growth and nutrient availability (Table 4-28).

Table 4-28. Percent deductions for reaction/nutrient status.

pH[1]	Percent deduction
7.0	0
6.0	0
5.0	10
4.0	20
3.0	30

[1] measured in saturated paste.

4.4.3.4. Subsurface salinity: (N)

A subsurface salinity deduction (Table 4-29) should be made **only** if it is greater than the deduction for the surface layer.

Table 4-29. Percent deductions for subsurface salinity.

Salinity dS/m[1]	Point deduction
4	0
8	10
16	20

[1] measured in saturated paste.

4.4.4. Drainage (W)

Organic soils are generally characterized by excess water in their natural state. However, uncontrolled drainage can lead to drought, high rates of subsidence, potential physical damage to the soil and increased erosion (and fire) hazard. The ratings focus on the continuing limitation rather than on the difficulty of development. As in the case of mineral soils, drainage is considered as a modifier of the main rating and is therefore managed as a percent deduction. There are three main aspects: depth to water table, hydraulic conductivity and regional climate (Table 4-30).

Table 4-30. Percent deduction for drainage.

Depth to water table (cm)[1]	Subsurface	Fibric			Mesic			Humic		
	Fibre content[2]	80	60	40	30	20	10	5		0
	von Post scale	1 2	3	4	5	6	7	8 9		10
	Hydraulic conductivity[3]	50	15	5.0	1.5	0.5	0.15			0.015
Standing water		100		100			100			100
0		90		95			100			100
25		75		80			85			85
50		50		55			60			65
75		25		30			35			40
100		5		10			15			20
125		0		0			0			0

[1] for the most limiting 20 day period.
[2] % rubbed fibre >0.15 mm.
[3] hydraulic conductivity in cm/h.

4.4.5. Calculation of Organic Soil Rating

Figure 4-1 should be used to calculate the organic soil rating. Do not use the **Phase 2 Transect Rating Form** in Appendix 3. The following steps are suggested.

1. The basic moisture factor is determined from the P-PE index and the bulk density (or fibre content or von Post index) of the surface layer using Table 4-21. Next, record the depth to water table and the bulk density of the material above the water table and, using Table 4-22, determine the water table adjustment. The Moisture deduction is the basic moisture factor minus the adjustment.
2. Determine and record the % fibre, pH and salinity values for the surface 40 cm. Using Tables 4-23, 4-24 and 4-25 assign appropriate point deductions and total them to give the Surface Factor deduction.
3. The Interim Organic Rating is 100 minus the Moisture and Surface Factor deductions from steps 1 and 2.
4. Determine and record for the subsurface the % fibre, the depth to and texture of an impeding layer, the pH and salinity values. Using Tables 4-26 to 4-29 assign appropriate percent deductions. Total the deductions and take as a percentage of the Interim rating determined in step 3 to determine the Subsurface deduction.
5. Subtract the Subsurface deduction in step 4 from the Interim Rating in step 3 to give the Basic Organic Rating.
6. Record depth to water table, % fibre and climatic moisture index for the drainage determination. Using Table 4-30 assign the appropriate drainage deduction. This percentage of the Basic Organic Rating determined in step 5 gives the Drainage deduction.
7. Subtract the Drainage deduction in step 6 from the Basic Organic Rating as determined in step 5 to give the Final Organic Rating.

ORGANIC SOIL RATING (O)

Factor	Value	Deductions
1. Moisture Factor (M)		
- P-PE index	_____	
bulk density/% fibre	_____	_____ a)
- water table depth	_____	
bulk density/% fibre	_____	_____% a) = _____ b)
Moisture deduction =	a)_____ - b)_____	= _____ c)

		Point Deduction
2. Surface Factors		
- structure (% fibre)(B)	_____	_____
- reaction (pH) (V)	_____	_____
- salinity (EC) (N)	_____	_____
Surface factor deduction =		_____ d)

Interim Organic Rating = 100 - [c) _____ +d) _____]= _____ e)

		Percent Deduction
3. Subsurface Factors		
- structure (% fibre) (B)	_____	_____
- substrate (G)		
texture	_____	
depth	_____	_____
- reaction (V)	_____	_____
- salinity (N)	_____	_____
Subsurface deduction =		_____% e) = _____ f)

Basic Organic Rating = e)_____ - f)_____ = _____ g)

4. Drainage Factor (W)		
- P-PE index	_____	
- water table depth	_____	
- bulk density/% fibre	_____	_____
Drainage deduction =		_____% g) = _____ h)

5. FINAL ORGANIC RATING (O) = g)_____ - h)_____ = _____

Limitations = _____, _____, _____

Figure 4-1. Organic soil rating form.

4.5. PROXIES AND OTHER SUPPLEMENTARY DATA

4.5.1. Mineral Soils

Most proxies, along with a brief explanation of how they are used, are listed with their appropriate factor rating (Table 4-31).

Table 4-31. Proxies used in the Phase 2 (soils) rating procedure.

Basic Soil Attribute	Common proxy	Table
Water holding capacity - mineral	Texture	4-1, 4-2, 4-3
- organic	Fibre content	4-21
Capillary rise - mineral	Texture	4-4
- organic		4-21
Hydraulic conductivity - mineral	Texture	4-18, 4-30
- organic	Fibre content	
Depth to water table	Soil drainage, natural vegetation	4-4, 4-18
Organic matter content	Soil colour	4-6
Salinity	Natural vegetation, soil features	4-9
Structure – organic	Fibre content	4-23
Bulk density - mineral	Structure, consistence, texture	4-33
- remoulded	Consistence	4-34, 4-35
- organic	Fibre content, von Post rating	4-36
Climatic moisture	P-PE index	4-32

Bulk density is a basic soil factor in the capability rating but is difficult and time consuming to measure. However, over the years, a body of knowledge has been accumulated on the relationship of bulk density to soil features such as structure, consistence texture and pedological horizon designation for natural, undisturbed mineral soils (Table 4-33).

We have less experience with reclaimed soils. If they have been extensively remoulded, they will usually be structureless (massive) and the bulk density can be related to consistence, the resistance to pressure. As a first approximation, Tables 4-34 and 4-35 are offered as a guide for assigning bulk density values for disturbed soils.

For organic soils, fibre content or von Post rating can be used in place of bulk density (Table 4-36).

The value of the climate index is not critical for transect comparisons. If one does not wish to estimate P-PE from the map, the relationships in Table A 4-2 can be used:

Table 4-32. Precipitation minus Potential Evapotranspiration (P-PE) proxy for soil zone or ecological region.

Ecological Region	Soil Zone	P-PE
Mixed Grass Prairie	Brown	-300
Mixed Grass Prairie	Dark Brown	-250
Fescue Grasslands	Black	-250
Parkland	Black	-200
Low Boreal	Dark Grey - Grey	-200
Other Boreal	Grey	-150

Table 4-33. Common relationships between kind of horizon, structure, consistence, texture and bulk density[1] in natural mineral soils.[2]

Kind of horizon	Common structure	Common consistence dry/moist	Texture class					
			S LS	SL	L SiL	CL SCL	SiCL SiC	C HC
Ah	granular	slightly. hard friable	1.30	1.20	1.15	1.10	1.00	0.95
Ae	platy, massive	soft, slightly hard, friable	1.45	1.40	1.35	1.30	1.30	-
Ap >1%OC	granular	friable	1.40	1.35	1.25	1.20	1.10	1.05
Ap <1%OC	massive	soft-hard friable-firm	1.40	1.40	1.40	1.35	1.30	1.25
Bm	subangular prismatic	slightly hard, friable-firm	1.50	1.45	1.40	1.40	1.35	1.30
Btj	prismatic	hard firm	1.55	1.55	1.50	1.50	1.40	1.35
Bt	blocky	hard-very hard firm-very firm	-	1.55	1.55	1.55	1.50	1.45
Btnj	blocky columnar	very hard very firm	-	1.60	1.60	1.60	1.55	1.45
Bnt	columnar blocky	extremely hard extremely firm	-	1.65	1.65	1.65	1.60	1.50
Bn	columnar massive	extremely hard extremely firm	-	-	1.65	1.65	1.60	1.50
Bf	weakly granular massive	slightly firm friable	1.40	1.30	1.10	0.90	-	-
B, Cc, BCx	massive	extremely firm	-	1.80	1.80	1.80	--	-
BC, C	massive ps.blocky	hard firm	1.55	1.55	1.50	1.45	1.40	1.35

[1] core method.

[2] the values given in this table were compiled from data published in soil survey reports, theses and other scientific publications as well as unpublished Alberta data.

Table 4-34. Relationship of structure, perviousness, compaction and rooting to bulk density for medium textured reconstructed subsoils[1].

Structure	Perviousness	Compaction	Rooting	Estimated bulk density
Dominant soil aggregates <2 cm diameter, very friable/soft or friable/slightly hard.				
crumb fine, medium subangular blocky.	moderate, many continuous cracks, pores	none slight	normal non-limiting	1.40
This category is equivalent to/includes mellow, AB, Bm, Btj, and some Bt, BC and C horizons.				
Dominant soil aggregates <2 cm in diameter, firm/hard.				
medium angular, & subangular-blocky.	moderate common continuous cracks, pores	moderate	slightly restricted	1.50
This category is equivalent to/includes many Bt, Btnj, some Bm, C horizons.				
Dominant soil aggregates 2 to 10 cm in diameter, very firm/very hard.				
coarse, very coarse subangular-blocky & angular blocky, medium prismatic	moderate common continuous cracks, pores	moderate-severe	moderately restricted	1.60
This category is equivalent to/includes many Bt, Btnj horizons, some C horizons				
Dominant soil aggregates 2 to 10 cm in diameter, very firm/very hard.				
cloddy, prismatic columnar.	slow, few cracks, pores	severe	restricted root mats, compressed roots, along cracks/peds	1.70
This category is equivalent to/includes many Bnt, Bn, C horizons.				
Dominant soil aggregates 10 to 30 cm diameter, extremely firm/extremely hard.				
cloddy, columnar, massive.	very slow, very few cracks, pores	severe-extreme	roots along cracks only	1.80
This category is equivalent to/includes some Bnt, C horizons.				
Soil is massive, aggregates >30 cm diameter, extremely firm/extremely hard.				
massive, bedded.	very slow, very few cracks, pores	extreme	no roots, root mat above restricting layer	2.0
This category results from compaction as in roads, heavy traffic areas, and includes soft bedrock deposits. This material can be augered with difficulty.				

[1] Modified through pers. comm. with L. Leskiw, Can-Ag Enterprises Ltd., Edmonton, Alberta.

Notes:

For layered, bedded materials, or compacted materials that have firmer/harder consistence, rate the most limiting part of a layer. Rate the most limiting structure or consistence.

Perviousness, compaction and rooting provide supporting evidence to rate the conditions. Perviousness is the capacity of the soil to transmit air and water.

Aggregation is determined by dropping a mass of soil (spade full) one metre onto a hard surface (plywood), and visually estimating the dominant size category of aggregates or soil clods.

Table 4-35. Relationship of moisture status, consistence and texture to bulk density in reconstructed soils.[1]

Moisture status	Consistence class	Description	Usual Texture[2]	Estimated bulk density
Moist	Loose	The soil material is non-coherent	S, LS	1.4
	Very friable	The soil material is crushed under very gentle pressure, but coheres when pressed together: the specimen fails under less than 8N of force (very gentle pressure).	VFSL, L, SiL	1.3
	Friable	The soil material is easily crushed under very gentle to moderate pressure between the thumb and forefinger and coheres when pressed together: the specimen withstands 8N, but fails under 20N (gentle pressure).	L, SiL, CL	1.4
	Firm	The soil material is crushed under moderate pressure between the thumb and forefinger, but resistance is distinctly noticeable: the specimen withstands 20N, but fails under 40N (moderate pressure).	L, CL, SiCL, C	1.5
	Very firm	The soil material can be crushed under moderate pressure between the thumb and forefinger but strong pressure is required: the specimen withstands 40N, but fails under 80N (80N force is near the maximum force that can be exerted between the extended thumb and forefinger for many people).	CL-C	1.6
	Extremely firm	The soil is very resistant to pressure: it can be broken in the hands only with difficulty, and can not be crushed between the thumb and forefinger: the specimen withstands 80N of force but fails under 160N (160N of force corresponds approximately to the force that can be applied slowly with a foot or by compression between two hands).	CL-C	1.8
Dry	Loose	The soil material is non-coherent	S, LS	1.4
	Soft	The soil material is weakly resistant to pressure and breaks to a powder or individual grains under very slight pressure: the specimen fails under less than 8N of force (very gentle pressure).	VFSL, L, SiL	1.3
	Slightly hard	The soil material is weakly resistant to pressure and easily broken between the thumb and forefinger: the specimen withstands 8N, but fails under 40N (40N of force corresponds tofirm pressure between the extended thumb and forefinger for many people but is significantly less than the maximum force that can be extended slowly).	L, SiL, CL	1.4
	Hard	The soil is moderately resistant to pressure: it can be broken in the hands without difficulty, but considerable pressure is necessary to break it between the extended thumb and forefinger: the specimen withstands 40N of force but fails under 80N (80N force is near the maximum force that can be exerted between the extended thumb and forefinger for many people).	L, CL, SiCL, C	1.5
	Very hard	The soil is very resistant to pressure: it can be broken in the hands only with difficulty, and is not breakable between the thumb and forefinger: the specimen withstands 80N of force but fails under 160N (160N of force corresponds approximately to the force that can be applied slowly with a foot or by compression between two hands).	CL-C	1.6
	Extremely hard	The soil is extremely resistant to pressure; and cannot be broken in the hands; the specimen withstands 160N of force but fails under 800N (800N is near the pressure of full body mass for many people).	CL-C	1.8
	Rigid	The soil material cannot be broken except by extreme pressure (>800N of force)	SL-CL	2.0
Wet	Stickiness classes	Stickiness is a measure of clay content and is not well related to bulk density. Wet consistence will not be used in this relationship		

[1] Consistence descriptions from Phase 1; bulk density estimates based on expert opinion.

[2] Consistence does not relate directly to texture. Classes given are the usual ones found in Alberta but are not exclusive.

4.5.2. Organic Soils

This Section provides a comparison of fibre content, degree of decomposition, bulk density, water holding capacity and hydraulic conductivity in organic soils.

As with mineral soils, key factors such as bulk density and various water relationships are often difficult and time consuming to obtain. The following relationships (Table 4-36) are taken from Land Suitability Rating System (Agronomic Interpretations Working Group 1995). It must be emphasized that these represent only general relationships to be used when more specific data are not available.

Table 4-36. General relationships between fibre content, bulk density and various water characteristics for organic soils.

Category	Fibric			Mesic			Humic		
% rubbed fibre [1]	80	60	40	30	20	10	5		0
% unrubbed fibre	90		60			30			
Von Post scale	1 2	3	4	5	6	7	8	9	10
Bulk density[2]	0.04	0.08	0.10	0.13	0.16	0.18	0.20		0.22
Average/category		0.07			0.15		0.20		
Water holding capacity	(% by volume)								
0 kPa/m (sat.)[3]	95		90			85			82
10 kPa/m (F.C.)[3]	30	40	50		66	72	71		70
1500 kPa/m (W.P.)[3]	6	10	12		16	20	21		22
"available water" [4]	24	30	38		50	52	50		48
"free drain water"[5]	65		40			13			12
Hydraulic conductivity[6]	50	15	5.0	1.5	0.5	0.15	0.05		0.015
ECSS categories	high		moderate			low			

[1] % rubbed fibre >0.15 mm.

[2] bulk density in Mg/m^3.

[3] sat.= saturation; F.C.= field capacity; W.P.= wilting point.

[4] available water = field capacity - wilting point.

5 free drain water = saturation % - field capacity.

[6] hydraulic conductivity in cm/h.

ECSS = Expert Committee on Soil Survey (1983).

5.0 REFERENCES

Agronomic Interpretations Working Group, 1995. Land suitability rating system for agricultural crops: 1. Spring-seeded small grains. Edited by W. W. Pettapiece. Tech. Bull. 1995-6E. Center for Land and Biological Resources Research, Agriculture and Agri-Food Canada, Ottawa, Ontario. 90 pages, 2 maps.

Alberta Agriculture, Food and Rural Development, 2000. Purity of native seed used for revegetation of natural landscapes. Public Lands Update IND 2000-2. Alberta Agriculture, Food and Rural Development, Edmonton, Alberta. 3 pp.

Alberta Environmental Protection, 1995. Reclamation criteria for wellsites and associated facilities - 1995 Update. Alberta Environmental Protection, Edmonton, Alberta. 62 pp.

Alberta Soil Series Working Group, 1993. Alberta soil names generation 2. Users Handbook. March 1993 Version. L. J. Knapik and J. A. Brierly (eds.). Alberta Research Council, Edmonton, Alberta.

Expert Committee Soil Survey, 1983. The Canadian soil information system (CanSIS): Manual for describing soils in the field 1982. Revised. Edited by J.H. Day. Land Resource Research Institute, Agriculture Canada, Ottawa. 162 pp.

Native Plant Working Group, 2001. Native plant revegetation guidelines for Alberta. H. Sinton-Gerling (ed.). Alberta Agriculture, Food and Rural Development, Edmonton, Alberta. 58 pp.

Soil Classification Working Group, 1998. The Canadian system of soil classification. Agriculture and Agri-Food Canada. Publication 1646 (Third Edition). NRC Press, Ottawa, Ontario. 187 pp.

APPENDIX 1: GLOSSARY OF TERMS

A more detailed glossary of reclamation and remediation terms can be found at www.gov.ab.ca/env/protenf/landrec/index.html under Publications.

Term	Definition
A horizon:	A mineral horizon formed at or near the surface in the zone of removal of materials in solution and suspension, or maximum accumulation of organic carbon, or both.
Admixed:	A mixture of soil layers; non-surface soil in the replaced surface soil, usually expressed as a percentage.
Ae:	A horizon that has been eluviated of clay, iron, aluminum, or organic matter, or all of these.
Aggregate:	A group of soil particles cohering so as to behave mechanically as a unit.
Ah:	A horizon in which organic matter has accumulated as a result of biological activity.
Ap:	A horizon markedly disturbed by cultivation or pasture.
B horizon:	A subsoil horizon characterized by one of: a) an enrichment in clay, iron, aluminum, or humus (Bt or Bf), b) a prismatic or columnar structure that exhibits pronounced coatings or stainings associated with significant amounts of exchangeable sodium (Bn or Bnt), or c) an alteration by hydrolysis, reduction, or oxidation to give a change in colour or structure from the horizons above or below, or both (Bm).
Bare areas:	Any areas greater than 1 m^2, on the RoW or the adjacent undisturbed land that do not have vegetation growing on them. On cultivated land, this does not include the areas between drill-seeded rows.
Bulk density, soil:	The mass of dry soil per unit bulk volume.
C horizon:	A mineral horizon comparatively unaffected by the pedogenic processes operative in the A and B horizons except for the process of gleying (Cg) or the accumulation of calcium carbonate (Cca) or other salts (Csa). A naturally calcareous C horizon is designated Ck.
Chroma:	The relative purity, strength, or saturation of a colour; directly related to the dominance of the determining wavelength of the light and inversely related to grayness; one of the three variables of colour.
Clod:	A compact, coherent mass of soil produced by digging, plowing or remoulding.

Term	Definition
Coarse fragments:	Rock or mineral particles >2.0 mm in diameter.
Conditional (site):	A Phase 1 rating with two "-1" failures (equivalent to about 65% to 80% of the control); or a Phase 2 rating that is 65% to 80% of the control.
Consistency:	(i) The resistance of a material to deformation or rupture; (ii) The degree of cohesion or adhesion of the soil mass. Terms used to describe a moist soil are - loose, very friable, friable, firm, very firm, compact, very compact, and extremely compact. Terms used to describe dry soils are - loose, soft, slightly hard, hard, very hard and extremely hard.
Control section:	The vertical section upon which soil classification is based.
Control:	Any pre-construction assessment information for undisturbed land on or off the RoW documented in the operator's application; or, any information collected by the operator from adjacent undisturbed land as part of a transect through the project RoW segment. The control provides comparison for the reclaimed RoW.
Cover:	Usually defined as the area of ground covered by all living (includes stems and leaves) and dead (litter) plant material that is produced naturally on a site, expressed as a percentage of the total area. Bare soil is not cover. This definition of cover is also referred to as ground cover, canopy cover or aerial cover. This is the type of cover that is referred to in the vegetation criteria. In a grassland it is important that cover be estimated, where possible, by looking directly down on the plants from above.
Density (plant):	The number of plants per unit area (e.g., per square metre). An individual plant can usually be defined as the sum of the aerial parts that correspond to a single root system. Plants that spread by underground roots are more difficult to count. In some cases, it may be appropriate to count individual stems. It may also be the number of plants of a particular species per unit area.
Drainage:	Soil drainage refers to the frequency and duration of periods when the soil is not saturated. Terms used are: excessively, well, moderately, imperfectly and poorly drained.
Equivalent land capability:	The ability of land to support various uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but the ability to support individual land uses will not necessarily be equal after reclamation.

Term	Definition
Fibre (rubbed):	Amount of fibre in an organic soil, greater than 0.15 mm, remaining after a specified amount of abrasion (rubbing). A fibric soil has greater than 40% rubbed fibre, a mesic soil has 10% to 40% rubbed fibre and humic soil has less than 10% rubbed fibre.
Fibric:	An organic layer containing large amounts of weakly decomposed material whose origins are readily identifiable.
Friable:	A consistency term pertaining to the ease of crumbling of soils.
Gravelly:	Containing appreciable or significant amounts of gravel (particles 2 to 75 mm in diameter).
Gyttja:	A nutrient rich sedimentary peat consisting mainly of plankton, other plant and animal residue and mud. It is deposited in water in a finely divided condition.
Hue:	One of the three variables of colour. It is caused by light of certain wavelengths and changes with the wavelength.
Humic:	An organic layer of highly decomposed material containing little fibre.
Hydraulic conductivity:	See permeability definition.
Impeded drainage:	A condition which hinders the movement of water through soils under the influence of gravity.
Indicator plants:	Plants characteristic of specific soil or site conditions.
Infiltration:	The downward entry of water into the soil.
Inspection site:	Any site where observations are recorded (see transect). For pipeline assessment, a transect across the RoW includes inspection sites on the trench (if readily identified), the RoW and an appropriate off-RoW control.
Line segment:	Any designated length of RoW. It will normally be 0.8 to 1.6 km (1/2 to 1 mile) to correspond with common ownership extents of ¼ sections and sections. It may contain one to several map units.
Litter:	Standing and fallen dead plant material that was produced naturally on site.
Map unit:	A map unit is any length of RoW, longer than the minimum length (50 m), which appears different from the rest of the RoW in terms of topography, vegetation or soils (see "problem unit").
Mesic:	An organic layer of intermediately decomposed material (between that of fibric and humic).

Term	Definition
Minimum size area:	50 m is considered as the minimum length for routine pipeline reclamation assessment considerations for Phase 1 and 2 (see Sections 2.2.1, "map units" and 2.2.2, "problem units").
Mulch:	Dead plant material (e.g., straw) that is added to a reclaimed site to help promote plant establishment by retaining soil moisture, increasing microbial activity and preventing soil erosion. It is not included in determining cover.
Munsell soil colour system:	A colour designation system that specifies the relative degree of the three simple variables of colour: hue, value, and chroma. For example: 10YR 6/4 is a colour (of soil) with a hue 10YR, value of 6, and chroma of 4. Value (grayness) can be used as a proxy for organic matter content.
Native species:	Plant species that are indigenous to a particular region; they were in Alberta prior to the time of Euro-American settlement.
Organic matter:	The decomposition residues of biological materials derived from: (a) plant and animal materials deposited on the surface of the soils; and (b) roots and micro-organisms that decay beneath the surface of the soil.
Particle size:	The effective diameter of a particle measured by sedimentation, sieving, or micrometric methods.
Peat:	Unconsolidated soil material consisting largely of organic remains (mainly derived from mosses or sedges).
Physical hazard:	Any physical feature such as logs, ridges or depressions that will interfere with normal land management.
Problem unit:	Any distinctly different (strongly contrasting) unit that is less than the specified minimum length required for a "map unit". It is a special case of a map unit for the recognition of very localized problems.
Quadrat:	A quadrat is a sampling area, usually square, of relatively small but constant size (often used to assess plant cover or density).
Rangeland:	A broad category of land comprising more than 40% of the earth's land area, characterized by native plant communities, which are often associated with grazing, and are managed by ecological, rather than agronomic methods. The term "range" can also include forestlands that have a grazing resource, or seeded lands that are managed like rangeland. Range resources are not limited to the grazable forage, but may include wildlife, water and many other benefits.

Term	Definition
Right-of-way – RoW:	All land acquired by the operator as RoW for the pipeline alignment. The RoW contains any and all surface disturbances resulting from the construction or reclamation of a pipeline and any pipeline infrastructure. RoW widths normally consist of a work area (about two-thirds), the trench, and a spoil area (about one-third). Extra work space may also be required for crossings, gradings, extra topsoil or spoil stockpiles, etc.
Roach:	The elevated ridge or mound over the backfilled trench resulting from spoil being displaced by the buried pipeline. The roach is either compacted or allowed to settle, and is feathered over the trench before topsoil or surface soil is replaced. If pipeline construction occurs under frozen ground conditions, the roach is allowed to settle under non-frozen ground conditions before topsoil or surface soil is replaced.
SAR (sodium adsorption ratio):	The proportion of sodium on the soil exchange complex in relation to the proportion of calcium and magnesium.
Saturation percentage:	The amount of water required to saturate a unit of soil (often correlated with sodicity).
Site:	See inspection site definition.
Soil structure:	The combination or arrangement of primary soil particles into secondary particles, unit or peds. These secondary units may be, but usually are not, arranged in the profile in such a manner as to give a distinctive characteristics pattern. The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades, respectively. Common terms for kind of structure are - single grain, amorphous, blocky, subangular blocky, granular, platy, prismatic and columnar.
Species composition:	The different types of plant seed or plants used to revegetate a disturbed area.
Spot failure:	See problem unit definition.
Subsite:	An observation around an "inspection site" to assess variability and relevance. For Phase 2 soils, this would include at least an augered inspection.

Term	Definition
Subsoil:	Although a common term it cannot be defined specifically. It may be the B horizon of a soil with a distinct profile. It can also be defined as the zone below the plowed soil in which roots normally grow. For Phase 2 it refers to the soil material between 20 cm and 100 cm depth.
Surface soil:	a) Phase 1: the upper 2 to 4 cm of mineral material or, in the case of poorly drained soils with more than 10 cm of peat, the upper 2 to 4 cm of organic material. b) Phase 2: For mineral soils, it is an average of the upper 20 cm of mineral material (or to a major root restricting layer if less than 20 cm or the organic layers if greater than 10 cm thick). For organic soils, it is the upper 40 cm of organic material (or to a mineral layer if less than 40 cm). Well to imperfectly drained L-F-H horizons are not considered for either Phase 1 or Phase 2.
Texture:	The relative proportions of sand, silt and clay (the soil separates). It is described in terms such as sand (S), loamy sand (LS), sandy loam (SL), loam (L), silt loam (SiL), clay loam (CL), silty clay loam (SiCL) and clay (C). See Figure 3-1, Section 3.3.3.
Topsoil:	The uppermost layer of mineral and organic material, valued as a growing medium, and ordinarily moved in tillage or its equivalent in uncultivated soils.
Transect:	A line across the RoW. It includes inspections on the trench (if identified), the RoW and an appropriate off-RoW control
Trench:	An excavation made within the RoW during pipeline construction, for containing the pipeline.
Value, colour:	The relative lightness of intensity of colour and approximately a function of the square root of the total amount of light. One of the three variables of colour.
Vigour:	The relative health of a plant. If a plant is vigourous, it is healthy and is performing as expected, in comparison with the surrounding vegetation or control.
von Post humification scale:	A manual method for estimating degree of decomposition of peat materials. It is a 10-point scale with assessment based on colour of drained water and structure of hand squeezed material.

APPENDIX 2: AN EXAMPLE ASSESSMENT

The following pages show how each Form is filled out using one of the sites assessed during the development of these criteria.

PHASE 1 TRANSECT DATA COLLECTION FORM

Location: SW XX-77-22-W4 Evaluator: Qualified Person Date: July 8/99
Map Unit: S2 Length: 200 m Transect #: S2-1 Photo: 99-6-1
General land use: forage (in rotation ??)
Landform notes: undulating with slopes of 2 – 5%; some wet depressions

Vegetation notes: generally uniform grass-alfalfa; some weedy patches

	Factor		Control	Right-of-Way	Trench
LANDSCAPE	Drainage	Temporary ponding	No	No	No
		Permanent ponding	No	No	No
	Coarse Fragments	Surface stoniness[1]	1-2	1-2	1-2
		Gravel (% by vol)	<5	<5	<5
	Micro-topography	Elevation change (cm)	None	None	5-10 cm
		Kind			Subsidence
		Number in unit	None	None	1
SOILS	Soil colour	(Munsell) (d or m)	3.5/1 d	3.5/1 d	4/2 d
	Aggregates	Dominant size	Med gran	Med gran	Med sub-blky
		Consistence	Friable	Friable	Firm
	Texture	Dominant class	L	L	L-CL
VEGETATION	Plant growth	Height	20 – 30 cm	20 – 30 cm	15 – 40 cm
		Density			
		Cover			
		Health	OK	OK	OK
		Distribution	Even	Even	Uneven
	Composition	Dominant species	Fescue, alfalfa	Fescue, alfalfa	Mainly alfalfa
		% weeds	<10	<10	10
		Kinds of weeds			Dandelion, thistle

[1] Can include wood or other obstructions on the surface.

Comments/Concerns:

- A few stones throughout, more variable on the trench (0-2)
- One short stretch (20 m) of slight subsidence
- Growth is good but somewhat uneven over the trench with a few weedier patches

PHASE 1 TRANSECT RATING FORM

Location: SW XX-77-22-W4 Evaluator: Qualified Person Date: July 8/99

Map Unit: S2 Length: 200 m Transect # S2-1

Component	Factor	Rating									
		Right-of-Way					Trench				
		+2	+1	0	-1	-2	+2	+1	0	-1	-2
Landscape	Drainage			☒					☒		
	Coarse fragments			☒					☒		
	Micro-topography			☒					☒		
	Frequency			3					3		
Soils	Colour			☒					☒		
	Aggregates			☒						☒	
	Texture			☒					☒		
	Frequency			3					2	1	
Vegetation	Growth			☒					☒		
	Composition			☒						☒	
	Frequency			2					1	1	
Frequency Total				8					6	2	

Pass ☐ Conditional ☒ Fail ☐ Phase 2 Required: No ☐ Yes ☒

Comments:

Special Circumstances:

PHASE 2 TRANSECT SOIL DATA INPUT FORM

1. LOCATION: SW XX-77-22-W4 NAME: Qualified Person DATE: July 8/99

   Map Unit: S2 Transect #: S2-1

   General Landform Position: mid-slope Climate (P-PE) index: -200

2. SOIL ATTRIBUTE DATA – Field Descriptions

Control

Horizon/ Layer # type	Depth	Texture*	Structure	Consistence	Munsell color	Salinity/other
1. Ap	0-15	L	Med gran	Friable	10YR3.5/1	
2. AB	15-25	L-CL	Mod med sub blky	Firm	10YR4/3	
3. Bt	25-70	CL	Str med blky	Firm	10YR4/4	
4. BC	70-100	L-CL	Mod large blky	Firm	10YR5/3	

* For organic soils use % rubbed fibre and % wood.

Depth to root limiting horizon: 25 cm

Drainage class: well Depth to water table:

Right-of-Way

Horizon/ Layer # type	Depth	Texture*	Structure	Consistence	Munsell color	Salinity/other
1. Ap	0-15	L	Granular	Friable	10YR3.5/1	
2. Ae	15-20	SiL	Granular platy	Very friable	10YR5/2	
3. AB	20-30	L-CL	Med sub blky	Firm	10YR4/3	
4. Bt	30-90	CL	Med blky	Very firm	10YR4/4	
Ck	90-100	L-CL	Large blky	Firm	10YR5/3	Weakly calcareous

* For organic soils use % rubbed fibre and % wood.

Depth to root limiting horizon: 30 cm

Drainage class: well Depth to water table:

Trench

Horizon/ Layer # type	Depth	Texture*	Structure	Consistence	Munsell color	Salinity/other
1. Ap	0-15	L-CL	Mod med sub blky	Firm	10YR4/2	
2. Sub1k	15-40	L-CL	Pseudo blky	Firm	10YR5/3	Weakly calcareous
3. Sub 2k	40-100	L-CL	Mass (fractured)	Very firm	10YR5/3	Weakly calcareous
4.						

* For organic soils use % rubbed fibre and % wood.

Depth to root limiting horizon: 40 cm

Drainage class: well Depth to water table:

COMMENTS: (variability, etc.)

PHASE 2 TRANSECT SOIL DATA INPUT FORM (continued)

1. LOCATION: SW XX-77-22-W4 NAME: Qualified Person DATE: July 8/99
   Map Unit: S2 Transect #: S2-1

2. SOIL ATTRIBUTE DATA – Chemical and Physical Data

Control

Horizon/ Layer	pH	Organic carbon	$CaCO_3$/ E.C.	Bulk density	Particle size*				Other
					>2mm	S	Si	C	
1. Ap	6.5	3.5		1.30	<5				L
2. AB	6.5	1.5		1.40	<5				L-CL
3. Bt	7.0	1.0		1.55	<5				CL
4. BC	7.0	0		1.50	<5				L-CL

* For organic soils use % rubbed fibre and % wood.

Right-of-Way

Horizon/ Layer	pH	Organic carbon	$CaCO_3$/ E.C.	Bulk density	Particle size*				Other
					>2mm	S	Si	C	
1. Ap	6.5	3.5		1.30	<5				L
2. Ae	6.0	2.0		1.3	"				SiL
3. AB	6.0			1.4	"				L-CL
4. Bt	7.0			1.55	"				CL
Ck	7.5			1.50	"				L-CL

* For organic soils use % rubbed fibre and % wood.

Trench

Horizon/ Layer	pH	Organic carbon	$CaCO_3$/ E.C.	Bulk density	Particle size*				Other
					>2mm	S	Si	C	
1. Ap	7.0	3.0		1.40					L-CL
2. Sub 1k	7.5		5%	1.50					L-CL
3. Sub 2k	7.8		5%	1.65					L-CL
4.									

* For organic soils use % rubbed fibre and % wood.

COMMENTS

- Organic carbon estimated from colour
- Bulk density estimated from structure, consistence and texture
- $CaCO_3$ estimated from effervescence

PHASE 2 TRANSECT RATING FORM

Factor	Control Value	Control deduction	RoW Value	RoW deduction	Trench Value	Trench deduction
1. Moisture Factor (M)						
- P-PE index	-200		-200		-200	
- AWHC/surface texture	L	20	L	20	L-CL	18
- subsurface texture	L-CL		L-CL		L-CL	
Texture deduction	=	20 a)	=	20 a)	=	18 a)
- water table depth	NA	%a) = b)	NA	% a) = b)	NA	%a) = b)
Moisture deduction	a) 20	-b) 0 = 20 c)	a) 20	-b) 0 = 20 c)	a) 18	-b) 0 = 18 c)
2. Surface Factors	Points deduction	Point deduction				
- structure/consistence (D)	gr fr	0	gr fr	0	sblky	3
- OM content (colour) (F)	3.5	1	3.5	1	3	2
- depth of top soil (E)	OK		OK		OK	
- reaction (pH) (V)	6.5	0	6.5	0	7.0	0
- salinity (EC) (N)						
- sodicity (SAR) (Y)						
- peat depth (O)						
fibre						
Interim soil rating	100 -[c) 20	+ 1] = 79 d)	100 - [c) 20	+ 1] = 79 d)	100- [c) 18	+ 5] = 77 d)
3. Subsurface Factors		% deduction				
- impeding layer (D, R)						
texture	CL		CL		L-CL	
structure/density	1.55		1.55		1.65	
depth	25	19	30	18	40	28
- contrasting texture						
- reaction (V)	7.0	0	7.0	0	7.5	0
- salinity (N)						
- sodicity (Y)						
Subsurface deduction	=	19 %d) = 15 e)	=	18 % d) = 14 e)	=	28 %d) = 22 e)
Basic Soil Rating	d) 79	-e) 15 = 64 f)	d) 79	-e) 14 = 65 f)	d) 77	-e) 22 = 55 f
4. Drainage Factor (W)						
- drainage class or depth to water table	NA		NA		NA	
Drainage deduction	=	%f) = g)	=	% f) = g)	=	%f) = g)
5. **FINAL SOIL RATING (S)**	= (f) 64	- (g) 0 = 64	(f) 65	- (g) 0 = 64	(f) 55	- (g) 0 = 55
Percent of Control		= 102 %				86 %

LINE SEGMENT RATING FORM

1. SEGMENT IDENTIFICATION

Legal: SW XX-77-22-W4

Assessor: Qualified Person Date: July 8/99

2. SUMMARY (Check appropriate categories).

Map Unit		Phase 1			Phase 2		
#	Length	Pass	Conditional	Fail	Pass	Conditional	Fail
S1.	400	☒	☐	☐	☐	☐	☐
S2.	200	☐	☒	☐	☒	☐	☐
S3.	200	☒	☐	☐	☐	☐	☐
4.	____	☐	☐	☐	☐	☐	☐
5.	____	☐	☐	☐	☐	☐	☐

Problem units		Phase 2			Comments
#	Length	Pass	Conditional	Fail	
1.	____	☐	☐	☐	
2.	____	☐	☐	☐	
3.	____	☐	☐	☐	
4.	____	☐	☐	☐	
5.	____	☐	☐	☐	

3. ASSESSMENT (Circle Pass or Fail).

Length of continuous failure:	0	(> 50 m = fail)	☒ Pass	☐ Fail
Length of discontinuous failure: (map units + problem spots)	0	(> 100 m = fail)	☒ Pass	☐ Fail
Length of Phase 2 conditional rating:	0	(>150 m = fail)	☒ Pass	☐ Fail

4. LINE SEGMENT RATING. ☒ Pass ☐ Fail

Comments/Special Circumstances.
Phase 2 confirmed that there was no major soil problem. This left only a single vegetation (weeds) issue and a short (20 m) stretch of minor subsidence and the line is passed.

APPENDIX 3: RATING TABLES AND DOCUMENTATION FORMS

This section contains the forms that must be filled in for each quarter section of land and attached to the reclamation certificate application.

PHASE 1 FACTOR EVALUATION SHEET

Landscape Rating

Drainage Rating

Description	Upland Rating	Wetland Rating
RoW and Control have the equivalent surface drainage.	0	0
Temporary or seasonal ponding on or caused by the RoW, not (previously) on the Control.	-1	-1
Temporary or seasonal ponding on the Control but not on the RoW.	+1	-1
Semi-permanent or permanent ponding on or caused by RoW, not on Control.	-2	-2
Semi-permanent or permanent ponding on the Control but not on the RoW.	+2	-2

Coarse Fragment Ratings

Description	Agricultural land rating	Range/forest land rating
RoW and Control have the same proportion of coarse fragments	0	0
Increase of 1 coarse fragment class; or 25% to 100% relative increase in gravel (by volume) between RoW and Control	-1	0
Decrease of 1 coarse fragment class; or 25% to 100% relative decrease in gravel (by volume) between RoW and Control	+1	0
Increase of 2 coarse fragment classes; or >100% to 200% relative increase in gravel between RoW and Control	-2	-1
Decrease of 2 coarse fragment classes; or >100% to 200% relative decrease in gravel between RoW and Control	+2	+1
Increase of 3 or more coarse fragment classes; or >200% relative increase in gravel (by volume) between RoW and Control	(-2)	-2
Decrease of 3 or more coarse fragment classes; or >200% relative decrease in gravel between RoW and Control	(+2)	+2

Microtopography Ratings

Description	Rating
<10 cm elevational difference between features on the RoW and similar features on the Control; similar number of features (rills, gullies, blowouts, roaches or subsidences)	0
Features on the RoW have 10 to 30 cm greater elevational difference than similar features on the Control; or 50% more features on the RoW than on the Control (rills, gullies, blowouts, roaches, etc.)	-1
Features on the RoW have 10 to 30 cm less elevational difference than similar features on the Control; or 50% less features on the RoW than on the Control (rills, gullies, blowouts, roaches, etc.)	+1
Features on the RoW have > 30 cm greater elevational difference than similar features on the Control; or 2x as many features on the RoW as on the Control (rills, gullies, blowouts, roaches, etc.)	-2
Features on the RoW have > 30 cm less elevational difference than similar features on the Control; or 2x fewer features on the RoW as on the Control (rills, gullies, blowouts, roaches, etc.)	+2

Vegetation Ratings

Ratings for Variation in Plant Growth

Growth Characteristics		
Cultivated/Forage in Rotation (tame)	Rating	Rangeland (native and improved)
RoW within 80% to 120% of the Control (within plus or minus 1/5 of the Control)	0	RoW within 65% to 135% of the Control value (within plus or minus 1/3 of the Control)
RoW within 65% to 80% of the Control (within 1/3 to 1/5 of the Control)	-1	RoW within 50% to 65% of the Control value (within 1/2 to 1/3 of the Control)
RoW within 120% to 135% of the Control (within 1-1/5 to 1-1/3 of the Control)	+1	RoW within 135% to 150% of the Control value (within 1-1/3 to 1-1/2 of the Control)
RoW less than 65% of the Control (less than 1/3 of the Control)	-2	RoW less than 50% of the Control value (less than 1/2 of the Control)
RoW greater than 135% of the Control (more than 1-1/3 times the Control)	+2	RoW greater than 150% of the Control value (more than 1-1/2 times the Control)

Ratings for Variations in Species Composition

Cultivated and Rangeland	Rating
Cover, type and extent of unsuitable plants on the RoW not distinctly different from the Control. RoW within 65% to 135% of the Control value for unsuitable species.	0
Cover, type and extent of unsuitable plants on the RoW contrasts with Control. RoW contains 135% to 150% of the Control value for unsuitable species.	-1
Cover, type and extent of unsuitable plants on the RoW contrasts with Control. RoW contains 65% to 50% of the Control value for unsuitable species	+1
Cover, type and extent of unsuitable plants on the RoW contrasts distinctly with Control. RoW contains 150% or more of the Control value for unsuitable species.	-2
Cover, type and extent of unsuitable plants on the RoW contrasts distinctly with Control. RoW contains less than 50% of the Control value for unsuitable species.	+2

Soil Ratings

Soil Colour Ratings

Description	Rating
RoW and Control have the same colour	0
Soil colour 1 to <2 units of value lighter on the RoW than on the Control	-1
Soil colour 1 to <2 units of value darker on the RoW than on the Control	+1
Soil colour 2 units (or more) of value lighter on the RoW than on the Control	-2
Soil colour 2 units (or more) of value darker on the RoW than on the Control	+2

Surface Texture Ratings

Description	Rating
RoW and Control have the same texture subgroup.	0
RoW differs from Control by one textural subgroup in a direction away from the "preferred" class.	-1
RoW differs from Control by one textural subgroup in a direction towards the "preferred" class.	+1
RoW differs from Control by two textural subgroups in a direction away from the "preferred" class.	-2
RoW differs from Control by two textural subgroups in a direction towards the "preferred" class.	+2

Surface Aggregate Size and Strength Ratings

Description	Rating
RoW and Control have the same aggregate size and strength	0
Change, between RoW and Control, of one aggregate size class in a direction away from the "preferred" class; or a change in one consistence class in a direction away from the "preferred" class	-1
Change, between RoW and Control, of one aggregate size class in a direction towards the "preferred" class; or a change in one consistence class in a direction towards the "preferred" class	+1
Change, between RoW and Control, of two aggregate size classes in a direction away from the "preferred" class; or a change in two consistence in a direction away from the "preferred" class	-2
Change, between RoW and Control, of two aggregate size in a direction towards the "preferred" class; or a change of two consistence in a direction towards the "preferred" class	+2

PHASE 2 FACTOR EVALUATION SHEET

Moisture Factors

Point deductions for combinations of available water holding capacity and the P-PE climate index.

Climate Index P-PE	% C+Si Texture[3] mm/m²	25	10 S 40	20 LS 60	40 SL 100	60 L 150	70 CL 170	75 SiL 180	80 C 190	85 SiCL 200	95 SiC 225	95 HC 225
0		40	15	0	0	0	0	0	0	0	0	0
-50		50	25	10	0	0	0	0	0	0	0	0
-100		60	35	20	10	0	0	0	0	0	0	0
-150		70	45	30	20	10	5	0	0	0	0	0
-200		80	55	40	30	20	15	10	10	10	10	10
-250		90	65	50	40	30	25	20	20	20	20	20
-300		95	75	60	50	40	35	30	30	30	30	30
-350		95	85	70	60	50	45	45	40	40	40	40
-400		95	90	80	70	60	55	55	50	50	50	50
-450		95	95	90	80	70	65	65	60	60	60	60

Point adjustment to water supply for subsurface texture

Average subsurface texture[1] (% clay + silt)		Average surface texture (% clay + silt) S (10)	LS (20)	SL (40)	L (60)	CL-C (>70)
S	(10)	0	+5	+15	+25	+30
LS	(20)	-5	0	+5	+15	+20
SL	(40)	-15	-5	0	+5	+10
L	(60)	-25	-10	-5	0	+5
SiL-C	(>70)	-30	-20	-10	-5	0

Percent reduction of moisture deficit by depth to water table

Depth of water table (cm)	Drainage Class	Texture of Subsurface coarse	medium	fine
0	very poor	100	100	100
25	Poor	90	90	90
50	poor – imperf.	60	70	75
75	Imperfect	20	40	50
100	imperf. - mod. well	0	10	20
125	mod. well – well	0	0	0

Surface Factors

Point deductions for surface soil structure and consistence

Structure	Consistence moist / dry	Point Deduction
Gran. subangular or fine blocky	friable/slightly hard	0
Blocky or platy	firm/hard	5
Single grained	loose/loose	5
Massive	very firm/very hard	10

Point deduction for depth of surface soil

Root restricting layer	Depth of surface soil 20	15	10	5	0
very firm, hard, massive, very calcareous or very acidic (Bt, Bnt, Bx or Cca horizon or strongly compacted layer)	0	5	10	15	20

Point deductions for surface organic carbon content

Organic Carbon %	Munsell colour value (dry)	Colour	Point deduction
>6	2	black	0
4	3	black	0
3	4	dark brown dark grey	2
2	5	brown, grey	5
1	6	grey	10
<1	7	light grey	15

Point deduction for surface soil pH saturated paste

Soil pH	Point deduction
9.0	60
8.5	20
8.0	5
6.0-7.5	0
5.5	5
5.0	15
4.5	30
4.0	55
3.5	80

Surface Factors (continued)

Point deduction for surface soil salinity

Salinity (dS/m)		Point deduction
2	no apparent signs	0
4	presence of foxtail, salt specks in soil	20
8	Kochia, white crusts common	50
16	samphire, salt crusts throughout	90

Point deductions for organic surfaces

Depth of peat (cm) non-compact	compact	Degree of decomposition	Point deduction
15	15	humic	5
20	15	mesic	5
25	15	fibric	10
30	30	humic	10
40	30	mesic	15
50	30	fibric	20

Point deduction for surface soil sodicity and saturation percent

Sodicity (SAR)	Saturation % (Sat%)	Point deduction
4	60	0
8	80	10
12	120	30
16	160	50
20	>160	80

Subsurface Factors

Percent deduction for bulk density and texture of impeding subsurface layer

Bulk density	% Clay texture	0 S	10 SL	20 L	35 CL	50 SiC	70 HC
1.25		0	0	0	0	0	0
1.30		0	0	0	0	0	0
1.35		0	0	0	0	0	5
1.40		0	0	0	0	5	15
1.45		0	0	0	5	15	25
1.50		0	0	5	15	25	35
1.55		0	5	10	20	35	45
1.60		5	15	20	30	45	55
1.70		25	30	40	50	60	80
1.80		45	50	60	70	85	-
1.90		65	75	85	90	-	-
2.00[2]		90	90	90	-	-	-
Rock -	90						

Subsurface Factors (continued)

Percent deduction for subsurface acidity (saturated paste)

Soil pH	Point deduction
6.0-7.5	0
5.5	2
5.0	5
4.5	15
4.0	30
3.5	55

Percent depth modifications for impeding subsurface layers

Depth (cm)	P-PE < -200*(subhumid)
20	100
40	80
60	60
80	35
100	10
120	0

Percent deduction for subsurface soil salinity

Salinity (dS/m)	Point deduction
<4	0
4	10
8	20
12	40
16	70

Percent deduction for subsurface soil sodicity and saturation percent

Sodicity (SAR)	Saturation % (Sat%)	Point deduction
4	60	0
8	80	10
12	120	30
16	160	50
20	>160	80

Percent deductions for soil moisture regime in regions with P-PE more negative than -200 mm (subhumid)

Depth to water table (cm)	Usual Drainage Class	Hydraulic conductivity (cm/h) low (<0.5)	medium (0.5-15)	high (>15)
standing water		100	100	100
0	very poor	90	90	90
25	Poor	70	65	60
50	poor-imp.	50	40	30
75	Imperfect	30	15	10
100	imp.-mod.well	10	0	0
>100	mod.well-well	0	0	0

PHASE 1 TRANSECT DATA COLLECTION FORM

Location:_____ Evaluator:_____ Date:_____
Map Unit: _____ Length: _____m. Transect #:_____ Photo:_____
General land use:_____
Landform notes: _____
_____
Vegetation notes: _____
_____

	Factor		Control	Right-of-Way	Trench
LANDSCAPE	Drainage	Temporary ponding			
		Permanent ponding			
	Coarse Fragments	Surface stoniness[1]			
		Gravel (% by vol)			
	Micro-topography	Elevation change (cm)			
		Kind			
		Number in unit			
SOILS	Soil colour	(Munsell) (d or m)			
	Aggregates	Dominant size			
		Consistence			
	Texture	Dominant class			
VEGETATION	Plant growth	Height			
		Density			
		Cover			
		Health			
		Distribution			
	Composition	Dominant species			
		% weeds			
		Kinds of weeds			

[1] Can include wood or other obstructions on the surface.

Comments/Concerns:

PHASE 1 TRANSECT RATING FORM

Location: _____ Evaluator: _____ Date: _____

Map Unit: _____ Length: _____m. Transect #: _____

Component	Factor	Rating									
		Right-of-Way					Trench				
		+2	+1	0	-1	-2	+2	+1	0	-1	-2
Landscape	Drainage										
	Coarse fragments										
	Micro-topography										
	Frequency										
Soils	Colour										
	Aggregates										
	Texture										
	Frequency										
Vegetation	Growth										
	Composition										
	Frequency										
Frequency Total											

Pass _____ Conditional _____ Fail _____ Phase 2 Required: No _____ Yes _____

Comments:
Special Circumstances:

PHASE 2 TRANSECT SOIL DATA INPUT FORM

1. LOCATION: _____ NAME: _____ DATE: _____
   Map Unit: _____ Transect #: _____
   General Landform Position: _____ Climate (P-PE) index: _____

2. SOIL ATTRIBUTE DATA – Field Descriptions

Control

Horizon/ Layer # type	Depth	Texture*	Structure	Consistence	Munsell color	Salinity/other
1.						
2.						
3.						
4.						

* For organic soils use % rubbed fibre and % wood.

Depth to root limiting horizon: _____

Drainage class: _____ Depth to water table: _____

Right-of-Way

Horizon/ Layer # type	Depth	Texture*	Structure	Consistence	Munsell color	Salinity/other
1.						
2.						
3.						
4.						

* For organic soils use % rubbed fibre and % wood.

Depth to root limiting horizon: _____

Drainage class: _____ Depth to water table: _____

Trench

Horizon/ Layer # type	Depth	Texture*	Structure	Consistence	Munsell color	Salinity/other
1.						
2.						
3.						
4.						

* For organic soils use % rubbed fibre and % wood.

Depth to root limiting horizon: _____

Drainage class: _____ Depth to water table: _____

COMMENTS: (variability, etc.)

PHASE 2 TRANSECT SOIL DATA INPUT FORM (continued)

1. LOCATION: _____ NAME: _____ DATE: _____
   Map Unit: _____ Transect #: _____

2. SOIL ATTRIBUTE DATA – Chemical and Physical Data

Control

Horizon/ Layer	pH	Organic carbon	$CaCO_3$/ E.C.	Bulk density	Particle size*				Other
					>2mm	S	Si	C	
1.									
2.									
3.									
4.									

* For organic soils use % rubbed fibre and % wood.

Right-of-Way

Horizon/ Layer	pH	Organic carbon	$CaCO_3$/ E.C.	Bulk density	Particle size*				Other
					>2mm	S	Si	C	
1.									
2.									
3.									
4.									

* For organic soils use % rubbed fibre and % wood.

Trench

Horizon/ Layer	pH	Organic carbon	$CaCO_3$/ E.C.	Bulk density	Particle size*				Other
					>2mm	S	Si	C	
1.									
2.									
3.									
4.									

* For organic soils use % rubbed fibre and % wood.

COMMENTS

PHASE 2 TRANSECT RATING FORM

Factor	Control Value	Control deduction	RoW Value	RoW deduction	Trench Value	Trench deduction
1. Moisture Factor (M)						
- P-PE index	_____		_____		_____	
- AWHC/surface texture	_____	_____	_____	_____	_____	_____
- subsurface texture	_____	_____	_____	_____	_____	_____
Texture deduction	=	_____ a)	=	_____ a)	=	_____ a)
- water table depth	_____	_____% a)= _____ b)	_____	_____% a)= _____ b)	_____	_____% a) = _____ b)
Moisture deduction	a) _____ - b)_____ = _____ c)		a) _____ - b)_____ = _____ c)		a) _____ - b)_____ = _____ c)	
2. Surface Factors		Point deduction				
- structure/consistence (D)	_____	_____	_____	_____	_____	_____
- OM content (colour) (F)	_____	_____	_____	_____	_____	_____
- depth of top soil (E)	_____	_____	_____	_____	_____	_____
- reaction (pH) (V)	_____	_____	_____	_____	_____	_____
- salinity (EC) (N)	_____	_____	_____	_____	_____	_____
- sodicity (SAR) (Y)	_____	_____	_____	_____	_____	_____
- peat depth (O)	_____	_____	_____	_____	_____	_____
fibre	_____	_____	_____	_____	_____	_____
Interim soil rating	100 - [c) _____ + _____] = _____ d)		100 - [c) _____ + _____] = _____ d)		100- [c) _____ + _____] = _____ d)	
3. Subsurface Factors		% deduction				
- impeding layer (D, R)						
texture	_____		_____		_____	
structure/density	_____		_____		_____	
depth	_____	_____	_____	_____	_____	_____
- contrasting texture	_____	_____	_____	_____	_____	_____
- reaction (V)	_____	_____	_____	_____	_____	_____
- salinity (N)	_____	_____	_____	_____	_____	_____
- sodicity (Y)	_____	_____	_____	_____	_____	_____
Subsurface deduction	=	_____% d) = _____e)	=	_____% d) = _____e)=	_____% d) = _____e)	
Basic Soil Rating	d) _____ - e) _____ = _____ f)		d) _____ - e) _____ = _____ f)		d) _____ - e) _____ = _____ f)	
4. Drainage Factor (W)						
- drainage class or depth to water table	_____	_____	_____	_____	_____	_____
Drainage deduction	=	_____% f) = _____g)	=	_____% f) = _____g)	=	_____% f) = _____g)
5. **FINAL SOIL RATING (S)** =	(f) _____ - (g) _____ = _____		(f) _____ - (g) _____ = _____		(f) _____ - (g) _____ = _____	
	Percent of Control		= _____ %		_____ %	

PHASE 2 ORGANIC SOIL RATING (O)

Factor	Value	Deductions
1. Moisture Factor (M)		
- P-PE index	_____	
bulk density/% fibre	_____	_____ a)
- water table depth	_____	
bulk density/% fibre	_____	_____% a) = _____ b)
Moisture deduction =	a)_____ - b)_____ = _____ c)	

		Point Deduction
2. Surface Factors		
- structure (% fibre)(B)	_____	_____
- reaction (pH) (V)	_____	_____
- salinity (EC) (N)	_____	_____
Surface factor deduction =		_____ d)

Interim Organic Rating = 100 - [c) _____+d) _____]= _____ e)

		Percent Deduction
3. Subsurface Factors		
- structure (% fibre) (B)	_____	_____
- substrate (G)		
texture	_____	
depth	_____	_____
- reaction (V)	_____	_____
- salinity (N)	_____	_____
Subsurface deduction =		_____% e) = _____ f)

Basic Organic Rating = e)_____ - f)_____ = _____ g)

4. Drainage Factor (W)		
- P-PE index	_____	
- water table depth	_____	
- bulk density/% fibre	_____	_____
Drainage deduction =		_____% g) = _____ h)

5. FINAL ORGANIC RATING (O) = g)_____ - h)_____ = _____

Limitations = _____, _____, _____

LINE SEGMENT RATING FORM

1. SEGMENT IDENTIFICATION

Legal: _____

Assessor: _____ Date: _____

2. SUMMARY (Check appropriate categories).

Map Unit		Phase 1			Phase 2		
#	Length	Pass	Conditional	Fail	Pass	Conditional	Fail
1.	_____						
2.	_____						
3.	_____						
4.	_____						
5.	_____						

Problem units		Phase 2			Comments
#	Length	Pass	Conditional	Fail	
1.	_____				
2.	_____				
3.	_____				
4.	_____				
5.	_____				

3. ASSESSMENT (Circle Pass or Fail).

Length of continuous failure:	_____	(> 50 m = fail)	Pass	Fail
Length of discontinuous failure: (map units + problem spots)	_____	(> 100 m = fail)	Pass	Fail
Length of Phase 2 conditional rating:	_____	(>150 m = fail)	Pass	Fail

4. LINE SEGMENT RATING (Circle Pass or Fail). Pass Fail

Comments/Special Circumstances.

APPENDIX 4. LANDOWNER PIPELINE RECLAMATION ASSESSMENT

Landowner views on the state of pipeline reclamation success must be collected, particularly as part of the reclamation certification process. **This section provides one method for collecting landowner views. Other methods are acceptable.** The form includes an assessment of landscape, vegetation and soils factors similar to those in the Phase 1 assessment. The evaluation is done independently by the landowner. Upon return of the completed forms the operator should record and evaluate the results. In cases where problems or concerns are noted, follow-up with the landowner is suggested.

It is suggested that the landowner's assessment be the first step in assessing pipeline reclamation success at the time of pipeline abandonment. Depending upon the outcome the reclamation criteria field evaluation might then be done.

Prior to mailing the package, the operator (pipeline company) should undertake to complete the site location information (pipeline name, operator, pipeline and regulatory contact, legal location). It is also recommended that a pipeline location map for the property be provided to ensure the landowner evaluates the correct line.

The following Landowner Evaluation Package is written as if the whole package was being mailed off to the landowner (i.e., references to "you" mean the landowner). It provides instructions on how to fill in the form. Operators may alter the format and/or content of the package.

LANDOWNER EVALUATION PACKAGE

The evaluation form on the following pages includes your assessment of selected landscape, soils, and vegetation parameters. For each parameter, check the appropriate box corresponding to whether you think the pipeline right-of-way (RoW) on your land is: At least 20% better than, as good as, or at least 20% worse than, the adjacent representative off-RoW control area. These parameters are key to evaluating abandoned pipeline reclamation success.

To help with the rating, there are *Guidelines for Parameters to Assess Reclamation on the Pipeline on Your Property* at the back of this package. Please feel free to provide whatever comments you wish to make in the Comments line for each item. Additional comments can be made under the General Comments category. Please provide an overall rating for the pipeline RoW in your quarter. If there are areas on the RoW which you feel are not acceptable, please mark them on the quarter section diagram. Please include comments about the nature of the problem and how much area it covers (for example, its length and width).

If there are any questions about which pipeline RoW this evaluation applies to, or any other concerns or questions in regard to the evaluation package, please call the contact provided in the cover letter to this package.

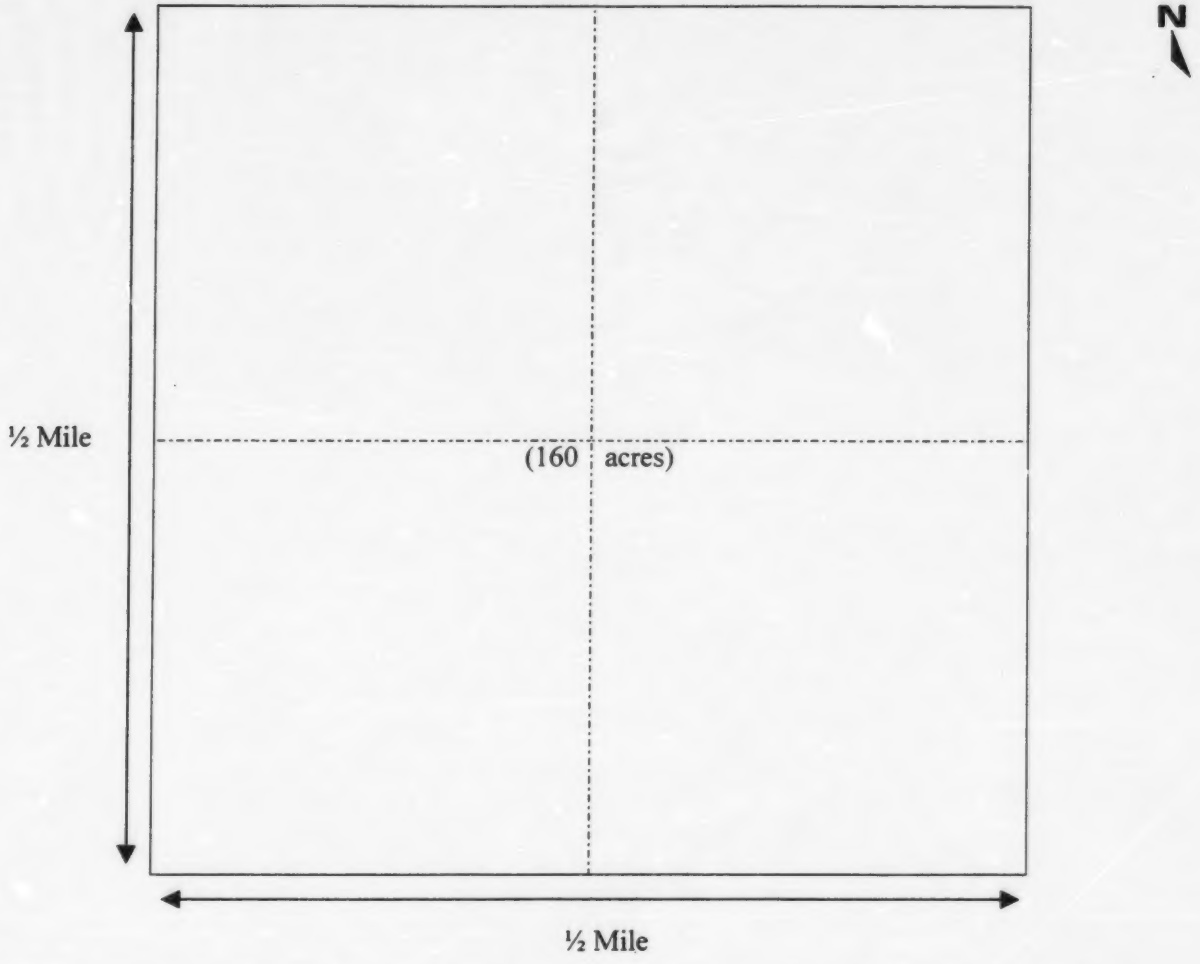
LANDOWNER PIPELINE RECLAMATION ASSESSMENT

Pipeline Name:	Date:
Pipeline Operator:	Pipeline Contact:
Landowner/Occupant name:	Legal location:
Address: _____ _____	Circle one: Public Land Private Land Telephone: _____ e-mail:
Evaluator (if different from landowner/occupant):	

The following ratings should be done independently by you. If another person manages the land, it should be completes with them. The comparisons of the right-of-way (RoW) are in relation to adjacent, representative off-Right-of-Way areas. Please check the box corresponding to the appropriate rating. Not all parameters need to be assessed. Use those you feel are appropriate to your land. Please also provide your overall assessment rating of the quarter as a whole at the bottom of the following rating form.

Parameters (see attached guidelines)	Right-of-Way (RoW) Condition Compared to off-RoW			
	At Least 20% Better	As Good As Off-RoW	At Least 20% Worse	Comments (Please include comments, including any physical hazards found on the RoW)
Surface Drainage/Ponding				
Stoniness				
Surface Roughness				
Topsoil Color				
Surface Clods				
Tilth				
Plant Cover or Density (circle the one used)				
Crop Yield				
Crop Growth				
Plant Species				
Weeds (specific kind)				
Overall assessment of the right-of-way over the quarter				

Legal Land Location: _____



The above frame represents one quarter section (1/2 mile by 1/2 mile). Please write the legal land location at the top. Draw the pipeline in the appropriate position across the quarter section, and mark with an "X" any locations that are rated "At Least 20% Worse". Also indicate the approximate extent of the area. This visual representation will help to locate any problem area more readily in the future for further assessment.

Please note that this form provides information for use in obtaining a reclamation certificate.

LANDOWNER SIGNATURE:_____ DATE: _____

GENERAL COMMENTS: _____

_____

_____

_____

Guidelines for Parameters to Assess Reclamation Success on the Pipeline on Your Property.

Parameters	Basis for Assessment	Description of Rating [on the right-of-way (RoW) compared to off the RoW]
Surface Drainage/ Ponding	Based on a visual assessment of the amount of standing or ponded water, and the ease of vehicle/equipment movement on-RoW versus off the RoW. Do you get stuck with equipment more, less or the same? Does water pond more, less or with the same frequency?	At least 20% less ponding of water or at least 20% better surface drainage
		Surface drainage and ponding approximately the same
		At least 20% more surface ponding or 20% worse surface drainage
Stoniness	Based on a visual assessment of the amount of stones and gravel, and tillage difficulty due to stoniness on the RoW versus off the RoW. Are there more stones or gravel on the RoW?	At least 20% less stones or gravel
		Approximately the same amount of stones and gravel
		At least 20% more stones or gravel
Surface Roughness	Based on a visual assessment of either water or wind erosion on the RoW versus off the RoW. Look at the number and depths of gullies, rills, blowouts, washouts, general erosion. Also, visually assess slope movement, slumping, and cracks in the soil on RoW versus off-RoW. Is the soil over the trench area lower, higher, or the same? How much rutting is there on-RoW versus off-RoW?	At least 20% less surface roughness
		Approximately same amount of surface roughness
		At least 20% more surface roughness
Topsoil Colour	Based on appearance of the topsoil color on-RoW versus off-RoW. Is the colour of the RoW soil lighter or darker or about the same colour as off-RoW?	Topsoil more than 20% darker in colour
		Topsoil approximately the same colour
		Topsoil more than 20% lighter in colour

Parameters	Basis for Assessment	Description of Rating [on the right-of-way (RoW) compared to off the RoW]
Surface Clods	Based on the number and hardness of surface clods on-RoW versus off-RoW. Are there more, less, or the same number, and do they fall apart as easily when kicked or stepped on?	Less than 20% as many clods and "softer" clods
		Approximately same amount and hardness of clods
		More than 20% as many clods and "harder" clods
Tilth	Based on the condition of the soil as related to its ease of tillage, fitness as a seedbed, ease of seedling emergence and ease of root penetration. Do the seedlings emerge the same both on and off-RoW? Is it as easy to till in both places?	At least 20% easier to till and grow seedlings
		Approximately the same tilth
		At least 20% harder to till and get seedlings to grow
Plant Cover or Density	Based on a visual assessment of live cover or the density of stems found on the RoW versus the amount of cover or density of plants off the RoW. Generally, how does the plant cover or density compare?	At least 20% more cover or density of stems
		Approximately same amount of cover or density of stems
		At least 20% less cover or density of stems
Crop yield	Based on the estimated crop yield on-RoW versus off-RoW. How does it compare in amount and tons per acre of hay, bushels of grain per acre, or range production of grass? How does the quality compare?	Crop yield at least 20% better
		Crop yield approximately the same
		Crop yield at least 20% worse
Crop growth	Based on appearance of plants - are the plants healthy, flourishing, normal growth form for the particular plant? How does the height of the plants compare?	Crop growth at least 20% better
		Crop growth approximately the same
		Crop growth at least 20% worse

Parameters	Basis for Assessment	Description of Rating [on the right-of-way (RoW) compared to off the RoW]
Plant Species	Based on your acceptance of the kinds of plants found on the RoW versus off the RoW, whether they are cereal crops, forage crops, or rangeland (including native species). Do the on-RoW plant species affect your management of the field the same as those off-RoW?	Plant species are at least 20% better
		Plant species are acceptable
		Plant species are at least 20% worse
Weeds	Based on visual assessment of how many weeds are found on the RoW versus off the RoW. Please specify kinds of weed by name (if known).	20% less weeds
		Approximately the same amount of weeds
		20% more weeds